University of Texas Bulletin
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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

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GEOLOGY AND MINERAL RESOURCES OF THE FORT STOCKTON QUADRANGLE[1]

BY W. S. ADKINS

INTRODUCTION

The Fort Stockton region was for centuries an Apache and Comanche camping ground. Indian graves, skeletons, implements and pottery have been found near Monument Spring, where there are also grinding holes in the limestone. The region was visited in 1684 by a Spanish army detachment under Mendoza, who killed buffaloes here. In 1839 merchants from Chihuahua City, contemplating a new road to rival the Santa Fe trail, came over the Chihuahua trail from Presidio and Paisano Pass through Pecos County. Emigrants to California crossed the Pecos at various well known fords and stopped at Comanche Springs on the way to El Paso. A military post to guard the mail route from San Antonio to El Paso was established at Comanche Springs in December, 1858, and was abandoned in May, 1861. In 1863 it was occupied by Confederate soldiers under General Sibley, but was soon abandoned. In July, 1867, under the supervision of General Phil Sheridan, Fort Davis and Fort Stockton were reoccupied, and on June 30, 1886, Fort Stockton was finally abandoned. Cleary[2] gave an excellent detailed description of the place in 1870. Of the eleven army post buildings he described, four still exist. In May, 1855, G. G. Shumard, geologist of the Pope expedition, traversed the eastern boundary of Pecos County and made

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[1]Manuscript submitted May, 1927, published October, 1927. An advance chapter, consisting of 32 pages of descriptions of well samples from Pecos County, was published in June, 1927.

[2]Assistant Surgeon P. J. A. Cleary: A report on barracks and hospitals and descriptions of military posts. Circular No. 4, War Department. Surgeon General Department, December 5, 1870. Government Printing Office, Washington.

notes on the geology.[3] Major Emory of the Mexican Boundary Survey in 1853–54 visited Leon Springs, where he made a collection of Lower Cretaceous fossils later described by Conrad.[4]

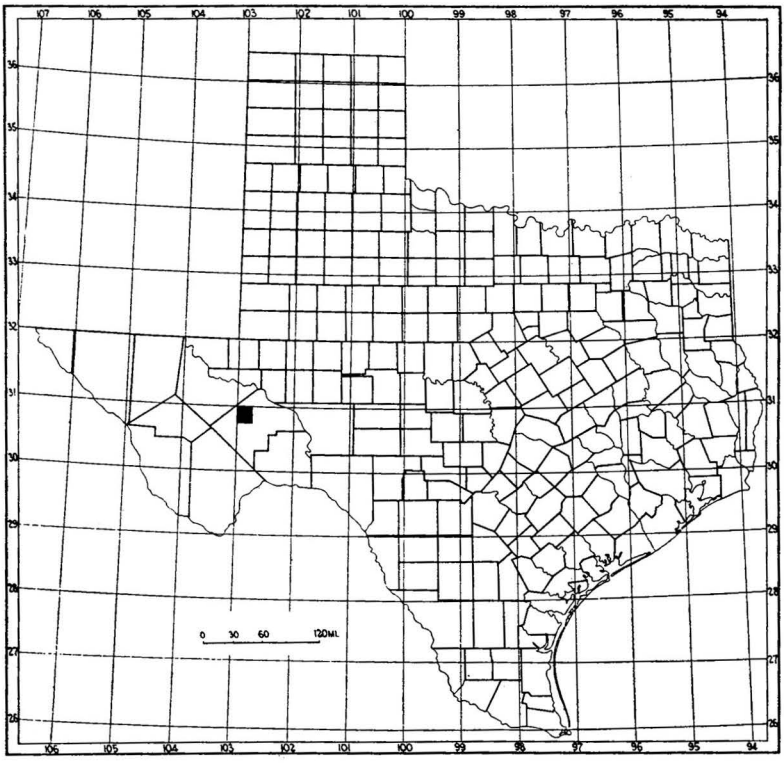

Fig. 1. Map of Texas, showing location of the Fort Stockton quadrangle.

The geologic column in Pecos County consists of a great thickness of Paleozoic, mainly Permian, rocks overlain by a considerable amount of Mesozoic, mainly Comanchean rocks. The Paleozoic is exposed in the southern part of the county

[3]George G. Shumard: A partial report on the geology of western Texas (etc.), Austin, 1886. (Pp. 74–82, 115–117.)

[4]T. A. Conrad: Description of Cretaceous and Tertiary fossils, in: William H. Emory, Report on the United States and Mexican Boundary Survey, Vol. I, Part II, p. 142 (1857).

in the uplifts of the Sierra Madera and the Marathon dome, and most of the rest of the county has Lower Cretaceous rocks at the surface. The sections of both Paleozoic and Cretaceous rocks are very different in northern and in southern Pecos County. In southern Pecos County the Paleozoic consists of "normal" formations, with considerable limestone; northwards these formations which have been reached by the drill (Permian) have changed largely into a saline series of red beds, salt, gypsum, dolomite, anhydrite, and other rocks produced in a desiccating sea and included in the western portion of the large West Texas Permian Salt Basin. The Cretaceous rocks of southern Pecos County are mainly hard limestones carrying rudistids at many levels; northwards these become thinner, partly by progressive overlap of the basal Cretaceous beds onto the older floor, and consist mainly of softer marls and marly limestones alternating with harder rudistid-bearing "caprocks."

The main features of geologic interest in the quadrangle are (1) the stratigraphy and structure of the Permian beds, and (2) the description of a standard section in the Lower Cretaceous.

Field work was done in 1920–21 and 1926. I am indebted to Dr. E. H. Sellards and to the Bureau of Economic Geology for information on wells; to Mr. H. L. Baldwin for well data, assistance in measuring sections, and information about localities; to Mr. I. T. Pryor for facts relating to exposures and wells; and to Judge O. W. Williams for historical and other information. To Dr. T. W. Stanton I am indebted for his unfailing generosity in giving information on Cretaceous fossils. Professor W. M. Davis has given much helpful advice on the study of the physiography of this region.

PHYSIOGRAPHY

Trans-Pecos Texas consists of two distinct parts, a western mountainous region, and a more eastern plains area. The inner edge of the plains lies at the foot of the Delaware, Davis, and Glass Mountains and the Santiago and

Boquillas (Carmen) ranges. The Fort Stockton quadrangle is situated on the Plains.[5] The region near this quadrangle consists of the following physiographic divisions:

1. Trans-Pecos Mountainous area (subdivision of the Basin Range Division)
    a. Mountains
    b. Intermontane depressions
2. Great Plains, southern continuation
    a. Stockton Plateau (and its eastern Canyon Sub-region)
    b. Toyah Basin

1. *Trans-Pecos Mountainous area.*—Southwards from the Rocky Mountains in New Mexico are isolated ranges which trend in a Rocky Mountain direction (NNW) and are separated and surrounded by reëntrants of the plains or by alluvial flats. Such ranges cross Trans-Pecos Texas and extend far into Mexico (as near Monterrey). In Texas the ranges rise to a maximum height of 4,000 feet, and an average of 1,500 feet above the plains, and are mostly surrounded by aggraded intermontane depressions with deep alluvium and gravel. This region is placed in the Rocky Mountain physiographic division by Blackwelder,[6] but it differs from the Rocky Mountains in having mountains surrounded by flats built up from mountain detritus, instead of intermontane valleys largely surrounded by mountains. Such features are characteristic of the Basin Ranges. The intermontane depressions consist of fill and slopes of rock waste, alluvium, bolsons, and salt and playa flats. The mountains of Trans-Pecos Texas are structurally intermediate between the Basin Ranges and the mountains farther south in Mexico. The Basin Ranges are supposed to be mainly block-faulted mountains; in northern Mexico anticlinal and domal uplifts with relatively unimportant faulting are the general rule; while in Trans-Pecos Texas some ranges are principally faulted and others are principally anticlines.

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[5]Some precise locations are given in: Clem L. Garner, Precise triangulation in Texas, Rio Grande arc. U. S. Coast and Geodetic Survey. Special publ. Serial No. 178, 1922 (p. 49).

[6]Eliot Blackwelder, Hdb., d. reg. geol, viii–2, United States, pp. 1, 150–161, 129 (footnote).

In the latitude of northern Pecos County it is doubtful if any true front range can be located, since the Davis Mountains, which barely enter the western corner of the county are apparently a SSE-trending syncline filled with shales and limestones and capped by lava flows, i.e., a lava-capped remnant forming the axial residual of a SSE-trending syncline.

The mountainous region does not enter the Fort Stockton quadrangle and will not be further discussed here.

2. *Great Plains.*—The plains slope northeast and east from the foot of the mountains towards the Pecos River, the only drainage outlet of the region. Emerging from the sloping surface of the plains are two uplifts exposing older rocks, the Marathon Dome (now unroofed and eroded to a basin) and the Sierra Madera, which lie within southern Pecos County. Stretching east and north from the mountains is a stripped and dissected tableland of nearly horizontal limestones known as the Stockton Plateau, an extension of the Edwards Plateau of Central Texas. The Stockton Plateau is a plain of (destructional) degradation, in which the formerly continuous limestone tablelands are being worn down and removed. It has some characteristics of the Great Plains, wide, nearly flat areas with a gentle seaward slope, in which the surface consists of irregularly beveled edges of successive formations. However, physiographic investigation has not proceeded far enough to clarify the exact relations of this area to the central interior Great Plains.

The Fort Stockton quadrangle lies near the northern edge of this plateau on the line of recession of its margin, and consists of lowlands (valleys and pediments), upland and outliers. The scattered outliers of the region are conspicuous. Northwards in Pecos County the limestone plateau is completely eroded away, exposing an underlying belt of soft shales, red beds, salt, gypsum and anhydrite. This region is characterized by its nearly even, monotonous surface, salt and playa flats, by considerable gravel fills, and by steppes vegetation. It has been called the Toyah Basin. In the eastern portion of Pecos County the Stockton Plateau

is deeply dissected by the Pecos River and its tributaries, and forms a sub-region of canyon topography with streams whose courses are not yet completely graded.

Uplands and Outliers.—The Fort Stockton quadrangle lies on a stripped plain of Cretaceous limestone formed by the removal of a great thickness of overlying softer beds, and now in a stage of immature dissection. The Davis Mountains, to the west of the quadrangle, are a shrinking erosional remnant of this widespread shale body and preserve under their lava cap the residual of a much more extensive outcrop. The hard limestones of this stripped plain form an upland whose summits lie mainly on one stratigraphic level, so that the region has generally a slope which coincides with the somewhat variable dip of the rock. This slope is in general NE or E, or locally SE, towards the Pecos River, but is irregular, especially in eastern Pecos County, because of the complicated surface structure. In southern Pecos County the upland is intact, but near Fort Stockton, following the southward recession of its edge there remain in front of the upland several small residual masses (outliers) of the stripped plain, which are in process of being consumed. Surrounding these outliers are graded slopes and pediments, some of them bare rocks and some mantled by detritus, connecting the higher land with the stream valleys. These stream valleys, with intermittent, presumably consequent streams, drain to the Pecos River.

Upland and outliers contain the same strata, weather by similar processes, and may be discussed together. The strata consist of about 600 feet of soft shales and limestones with three more resistant limestone ledges (Caprocks) interspersed. The mass is in the stage of down wearing to the main resistant ledges, accompanied by a recession of its front. At most places near Fort Stockton the Lower Caprock is not prominently exposed, the valley fill having covered it. The softer strata weather readily, and the rate of erosion is in part controlled by the three caprocks which act as principal cliff-makers. Over most of the region the upper caprock is absent by erosion, and the more resistant middle caprock caps the remaining strata. However, on

both upland and outliers the upper caprock when it is on the point of disappearance remains in isolated patches, which are generally left near one edge of the rock mass. In eastern Pecos County the upper caprock is widespread. Near Fort Stockton the edge of the upland is a prominent, generally north-facing scarp, but farther east its form is extensively controlled by the cutting of east-flowing streams which empty into the Pecos. In the Fort Stockton region the lower caprock is exposed only in the faces of upland and outliers, but farther east it is locally laid bare by the removal of the upper cliff-makers.

Throughout the region these hard and soft beds produce a characteristic profile. The upper caprock, if nearly consumed, forms a small, rather flat residual area; where more remains, it and the small thickness of overlying limestones form a gently rounded profile. Under it is a steep slope of softer limestone beds, generally free from talus. By means of a gently sloping platform, beveling soft beds and strewn with talus, this slope connects with the rounded projecting middle caprock. Beneath this is a steep cliff face, a gentle platform, and a projecting ledge (lower caprock). Where the strata under a caprock are limestone, the slope has an angle steeper than the critical angle at which talus will rest. On slopes the talus is in a process of refinement, and slab-talus has a different disposition from the common detritus produced from the marly limestones of this region. Where the upper caprock is present, double or "two-story" mesas result; where the middle caprock caps the residual, a single or "one-story" mesa or cuesta results. Beneath the lower caprock are alternate harder and softer limestone beds; the harder beds make small cuesta faces, and the softer beds small depressions lying on the back slopes of the cuestas. In southeastern Pecos County, where the facies changes and the section consists almost entirely of solid limestone, this profile disappears, but even there some topographic effect from the caprocks may still be traced.

In profile the steeper cliff faces end at their base in a graded slope, which lies between the foot of the cliff face

and the valley below. This condition is universal in this region, and its properties approximate those of a *pediment*, in the sense of McGee, Paige and Kirk Bryan.

A Mountain Pediment is a "plain which lies at the foot of mountains in an arid region or in headwater basins within a mountain mass. The name is applied because the plain appears to be a pediment upon which the mountain stands. A mountain pediment is formed by the erosion and deposition of streams, usually of the ephemeral type, and is covered with a veneer of gravel in transit from higher to lower levels. It simulates the form of an alluvial slope."[7]

Although the Fort Stockton region is not at the foot of a mountain, these slopes have the main characteristics of pediments, and it is believed that the name may be applied to them. They occupy a similar position in relation to the the uplands and outliers, their gravel veneer is thin, and they are surfaces of transportation in equilibrium in respect to the intake and outgo of detritus which is in transit across them. The major part of the Fort Stockton quadrangle may be considered as a set of coalescing pediments which, having during the recession of the uplands expanded laterally in following the consequent drainage upstream from the Pecos, now lie at the foot of the upland and around the outliers and are being extended headwards with the consumption of the higher land. As the land becomes worn down by neighboring streams, the retreating spur ends between are the points of coalescence of the pediments. Upon the pediments is located the consequent, mainly intermittent drainage of the region.

Some of these spur ends are cut off as outliers. The consumption of outliers and the consequent encroachment of alluvium up their slopes have left scattered over the quadrangle small residual mounds, which are surrounded, and are nearly or entirely covered, by alluvium or caliche. The talus and alluvium surrounding these reduced or consumed outliers may be taken to illustrate the "pan-fan" stage of

[7]Kirk Bryan: Erosion and sedimentation in the Papago country, Ariz., with a sketch of the geology. U.S. Geol. Surv. Bull. 730–B, p. 88, 1922.

Lawson. Until it is demonstrated that these are portions of a widely distributed set of mountain pediments (from the Davis or the Glass Mountains), extending out for considerable distances from the mountains, it would possibly be better to refer to them as plateau pediments.

Processes of Erosion.[8]—Erosion includes the processes of weathering, corrasion, and transportation. In this region the main processes of weathering seem to be splitting (spalling) and corrosion. Exfoliation is inconspicuous in these medium or thin-bedded rocks. The splitting is produced on a large or a small scale, in small chunks or in large rock masses. As the caprocks of mesas recede by undercutting of softer beds, large slices are split off by straight vertical clefts parallel to the edge. Such clefts 5 feet wide, 50 feet deep, and 100 feet or more long may be seen on the University and Seven Mile Mesas. These blocks eventually topple over and are broken up and consumed on the slopes or pediments. Blocks of all smaller sizes split off and fall. Their original splitting and their later refinement are produced partly by water action and partly under insolation, during which the outer shell heats and cools more rapidly than the inner portions, or different materials composing the rocks have different coefficients of expansion,

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[8]References on physiography of West Texas and related arid regions: Baker, Charles Laurence, Univ. Texas Bull. 1752, especially pp. 124–127, 134–139. Blackwelder, Eliot, Desert Weathering. Geol. Soc. Amer., 1926. Bryan, Kirk, Erosion and sedimentation in the Papago country, Ariz., with a sketch of the geology. U. S. Geol. Surv. Bull. 730–B, 1922. Davis, W. M., The geographical cycle in an arid climate, Jour. Geol. 13, 381–407, 1905. Fenneman, N. M., Physiographic provinces and sections in western Oklahoma and adjacent parts of Texas. U. S. Geol. Surv. Bull. 730–D, 1922, especially pp. 126–134. Hill, R. T., Descriptive topographic terms of Spanish America, Nat. Geogr. Mag., VII, Sept., 1896. R. T. Hill, U. S. Geol. Surv., 21 Ann. Rept., pt. 7, pp. 29–58, 1901. Johnson, Willard, The high plains and their utilization, U. S. Geol. Surv., 21 Ann. Rept., pt. 4, 601–741, 1901; 22 Ann. Rept., pt. 4, 631–669, 1902. Lawson, A. C., The epigene profile of the desert. Univ. Calif. Publ., 9, no. 3, 23–48, 1915. W. H. Streeruwitz: Geol. Surv. Texas, 4th Ann. Rept., 143–146, 1893.

thus setting up in the rock unequal expansions and contractions, resulting in flaking and splitting either near the surface or along lines of weakness, such as joints and calcite veins. These veined rocks after exposure show differential erosion. The summer rock temperatures in this region are known to be high. Frost and freezing play a certain, but unknown part in this refinement of the rock. Rain water produces an appreciable effect. Corrosion in etched potholes in the Fort Stockton region has been described by Udden.[9] The corrosion is stated to be in part due to the acid by-product of algae and removal of contents by wind action. The prevalent "schratten" weathering in this region is a corrosive effect. In limestone regions like Fort Stockton corrosion is evidently a principal agent in weathering. As in other arid regions, the main effect of weathering is disintegration, not decomposition.

Blackwelder[10] in summarizing the factors which operate in desert weathering minimizes the effects of frost action, stream corrasion and changes of temperature, and emphasizes the effects of diastrophism and of chemical changes, chiefly hydration and oxidation, which cause the swelling and mechanical crumbling of the rock. Much that has been written on desert weathering is speculation. Streeruwitz,[11] however, has published certain observations on the Trans-Pecos region. He stresses three main effects, temperature changes, sand blasts, and chemical action of water. In the granitic rocks of the higher parts of the Quitman Mountains, in summer and in winter, he observed a crackling noise produced by the flaking and disintegration of small scales from the rock, and loud reports from the splitting of huge boulders. This agency is active in rocks composed of heterogeneous materials. As observed by Walther and others, a protective crust, formed by iron salts, aided by ozone, prevents scaling. Streeruwitz records that the rains

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[9]J. A. Udden: Etched Potholes. Univ. Texas Bull. 2509, 1926.

[10]Eliot Blackwelder: Desert weathering. Geol. Soc. Amer., Preliminary list of titles and abstracts, 1926.

[11]W. H. Streeruwitz: Geo. Surv. Texas, 4th Ann. Rept., 1893, pp. 143–146.

clear these mountain tops of loose detritus, and that a month later, an inch of freshly made sand has accumulated. Streeruwitz claims that the scouring effect of sand at velocities of twenty-five miles an hour is an important agent of weathering, and that cold showers falling on heated rocks in summer split the rocks. Walther[12] notes that the shaded and lower parts of rock masses retain water longest, and that chemical action and disintegration are most rapid in these parts; mushroom-shaped masses of rock result. Streeruwitz considers this an important effect in west Texas. Walther (pp. 22–23) mentions that in the Nubian sandstones, inscriptions from the year 1500, if in the sunshine, are on the average better preserved than shaded inscriptions from the Nineteenth Century.

Transportation is effected by creep, by streams (mainly intermittent, sometimes torrential), and by sheet-water. Creep is effective on those portions of cliff slopes capable of retaining talus, on pediments, and on the sides of valleys. The detritus from the uplands, in crossing pediments, is gradually reduced in size. Writers have given maximum sizes for such transported materials across pediments, but no exact sizes can be given for this region. The material is of fairly small size, and inspection of water wells shows the mantle to be of slight thickness, less than 50 feet and at many places less than 10 feet. Sheet floods, somewhat like those described by McGee and others have been observed near Fort Stockton, and are one agent in transportation. The Sheffield road runs near the junction of the pediments surrounding Seven and Five Mile Mesas and after heavy rainfall the run-off resembles sheet floods. Various short wet-weather streams crossing the pediments transport and distribute the material, but to what extent is unknown.

The main drainage channels of the area are draws and arroyos.[13] Draws are wide valleys with a rather straight

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[12]Johannes Walther: Die Denudation in der Wüste.

[13]Fenneman, loc. cit., p. 127. Kirk, Bryan: Date of channel trenching (arroyo cutting) in the Southwest. Sci., LXII, 338–344, 1925. O. F. Evans: Stream Valleys of the Interior Plains Region. A.J.S. (V) XIII, 257, 1927.

intrenched channel, whose bottom is generally covered with rounded boulders and cobbles. The shape of the trench is controlled by torrential rainfall and the widening of the valley is probably produced by recession of the valley sides rather than by meanders. Such are Coyanosa Draw and Six Shooter Draw. The Fort Stockton region has since Indian days been noted for its large springs. On account of these it was long a camp site and later a meeting point of trails and roads. The springs drain through non-intrenched channels in shallow, rather straight valleys, and in a few miles disappear into the ground. Some of the largest sulphur water wells in Texas, north of Fort Stockton, discharge by similar streams, which disappear after three or four miles. The main drainage of this quadrangle consists of sub-parallel dip-slope consequents running northeast to the Pecos.

The alluvial flats are valleys of aggradation, and contain a thicker and more refined mantle of detritus and soil than the pediments. When these detritus-bearing streams reach lower courses of less gradient, the load is partly deposited. The same effect results from the disappearance of water underground, whether by deeper water table, cavernosity, or solution channels, and by evaporation in arid climates. The valley fill thus tends to encroach on the pediments and except for the operation of other factors would bury them. In addition, as the uplands wear down, their higher cliff-makers recede and form part of a slope of low gradient. Opposed to aggradation are run-off of detritus-bearing streams to the Pecos, and wind transportation. No quantitative estimate of either can be given for this region. East of Fort Stockton the trenching effect of the streams is prominent, but northwards the drainage of the quadrangle runs into the salt-basin flat bordering the Pecos, and its erosional effect has not been estimated. Dust storms are a conspicuous feature of the semi-arid regions of West Texas. Wind erosion and transportation reduce the uplands and build up the flats, or by removing fine material to outside the region even reduce the region as a whole.

These effects must be considerable, but without the collection of special data, it would be useless to attempt an estimate of the importance of wind transportation in this area.

Stage of Physiographic Development.—No high gravels or evidences of late peneplanation have been found in the Fort Stockton quadrange. High upland gravels have been reported from the tops of mesas (?Mainstreet) in eastern Pecos County, but not enough evidence is at hand to prove definitely the existence of peneplanation at this level. Baker suggests a late peneplanation in the Great Plains region in Texas, of possible Pliocene age and nearly contemporaneous with the main Balcones faulting in central Texas or with the extensive peneplanation and deposition of the Uvalde-Lafayette gravels gulfwards from that fault. It is notable that the Rio Grande and Pecos River are characterized by intrenched canyons, which may indicate a late date of cutting, and that at some places the Rio Grande appears to be an antecedent stream. Any such peneplain if originally present in the Fort Stockton quadrangle has been too extensively removed to leave decisive evidence as to the nature and date of the peneplanation. No terraces and no positive records of Pleistocene vertebrate fossils are known from Pecos County, but there are such records from adjoining counties.

STRATIGRAPHY

PALEOZOIC

PERMIAN

The Permian rocks of the Fort Stockton quadrangle and the immediate vicinity are divisible into three series of yet unnamed formations, which are the supposed correlatives of some of the higher formations exposed in the Glass Mountains. These are:

C. Red Beds series.
B. Salt series.
A. Lime series.

RED BEDS SERIES

Near Fort Stockton the upper part of the Red Beds is, with minor variations, the same in several wells. The upper 900 feet consist mainly of red shale or silty shale, as detailed in the sample descriptions (pp. 107–137.) There are subordinate amounts, mainly in thin seams, of sand, sandstone (maroon, red, green, brown), shale, sandy shale and limestone. If any Triassic is present in the area it overlies these Permian red beds. In the Quinby Townsite well there are records of maroon, red and green shales, some of them with appreciable amounts of muscovite. These also occur in the Oregon-Tex well. Samples from other wells give phosphate tests. The top portion, beneath the first Red Beds, in the Townsite well, has a notable amount of sand interbedded with thin seams of red clay. Beneath this upper 900 feet but above the salt are beds with predominant anhydrite or gypsum (some limestone), with or without red beds. In the top part of these beds ordinarily are sands with sulphur water. In the Thomas well, this basal part of the Red Beds series consists mainly of anhydrite, with thin seams of red clay, in the Pinal Dome well red clay and some limestone predominate.

In Western Pecos County, Section 89, Block OW there is found about the same section as at Fort Stockton. In the Hershenson (Dixie) well, however, beneath the main Red Beds and above the salt is a set of anhydrite beds (some dolomite, limestone, red beds and sand) 1,630 feet thick, which forms the lower part of the Red Beds series; this mainly consists of thick masses of anhydrite, among which seams and thin bodies of the other materials are scattered. At some places (Section 19–20, Block 140, and Buell and Hagan's University No. 1) the Red Beds are thin or absent, possibly by structural uplift and subsequent erosition, possibly by sedimentary overlap. The stratigraphic relations at these places have not been fully worked out.

In Eastern Pecos County the Corder well has the thinnest Red Beds above the salt (about 165 feet), the Noelke and the Blackstone and Slaughter wells next thicker; and the Sherbino wells have about 450 feet. The Perry and the

White and Baker wells show irregular, mostly smaller, thicknesses. Evidently the Red Beds are thickening gradually away from the Glass Mountains. On high lime structures they are reduced or absent; in these places the structural situation (overlap, subsequent erosion) is not entirely clear. The accessory materials, mainly in thin seams, are sand, shale, limestone, and more rarely anhydrite.

SALT SERIES

Near Fort Stockton the salt proper is not as prominently developed as either to the east or to the west. The Townsite well found salt scattered over a thickness of about 325 feet, apparently in thin seams interbedded with anhydrite or gypsum. The Pinal Dome well had salt scattered in beds of 100 feet or less thickness over an extent of 725 feet, and the interbedded material was mainly red beds at the top and anhydrite at the bottom. Beneath this in both wells is a considerable thickness of mainly anhydrite (some dolomite and limestone), lying above the top of the main lime series. Most wells north of Fort Stockton which went deep enough to have reached the salt found it missing on high structures or else absent by non-deposition. In the southern part of the quadrangle the situation is unknown.

In western Pecos County the Hershenson (Dixie) well penetrated a thick salt series, the top part of which consists of thick salt beds with some interbedded anhydrite and limestone, and the bottom part is anhydrite with a little limestone or dolomite.

In eastern Pecos County, the wells nearest the Glass Mountains (Noelke, Corder) have the salt very reduced and scattered. The Harral well has a greater aggregate thickness of salt, in thin seams interbedded mainly with red beds. The other wells, except those near the river, have a normal somewhat variable thickness of salt for this part of the county; the interbedded materials are red beds, anhydrite, some limestone, and some dolomite. The Perry (Plymouth) well has a small scale commercial production of salt. The lower portion of the salt series, below the salt proper, consists of beds of anhydrite, dolomite, sand, and locally Red Beds.

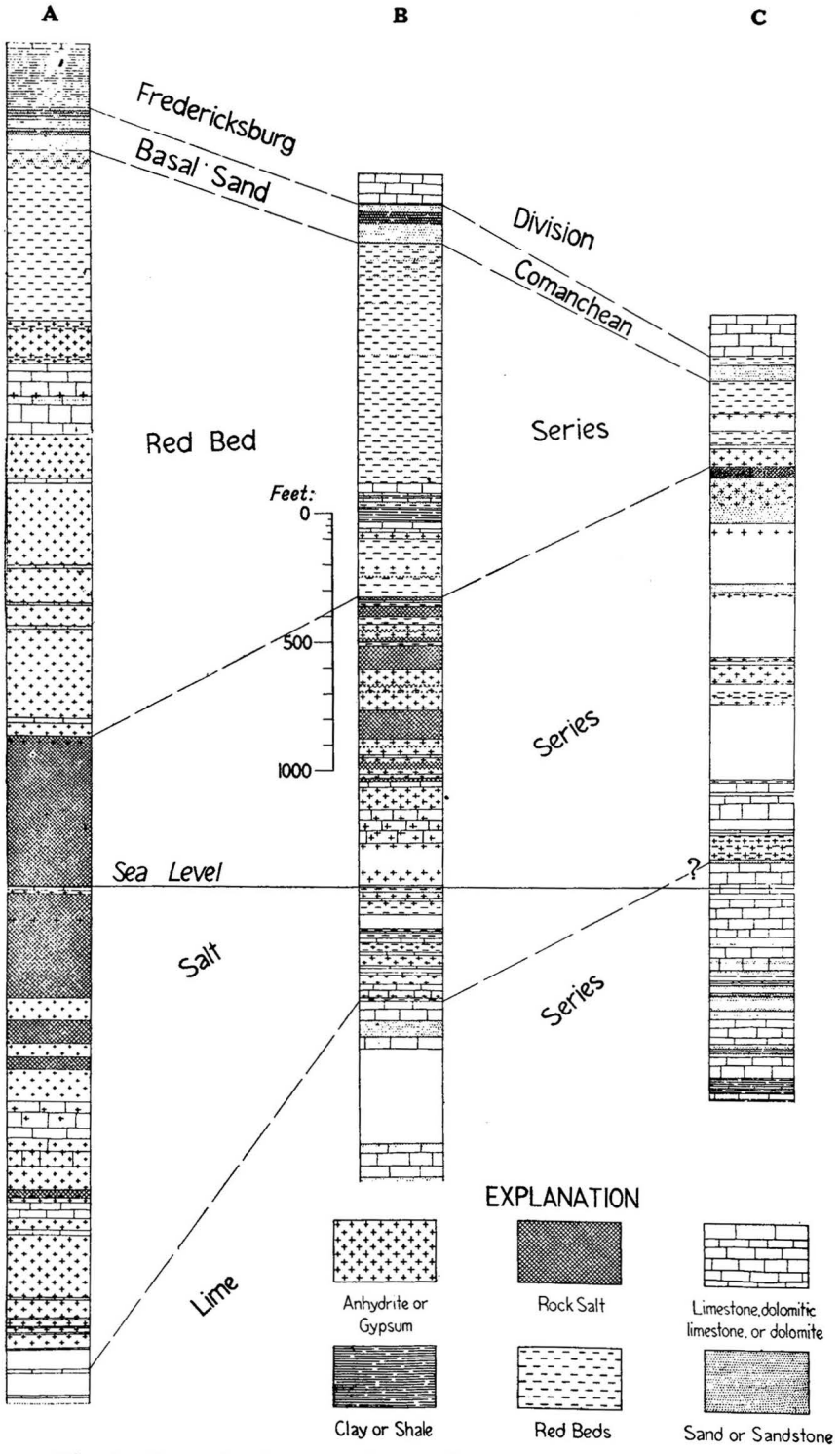

Fig. 2. Logs showing Permian sections in northern Pecos County. A, Hershenson 1 (Dixie); B, Devlin 1 (Pinal Dome); C, Noelke 1 (Reilly).

LIME SERIES

Near Fort Stockton the Pinal Dome well found, beneath the lowest red bed, about 700 feet of limestone with some water-and oil-bearing sand near the top, and some dolomite and water-bearing sand near the bottom. The Townsite well had about 250 feet of limestone in the bottom of the hole, which has been assigned to the main lime series.

In western Pecos County the Hershenson (Dixie) well struck a lime, correlated with the Delaware Mountain formation at about 5,200 feet depth.

In eastern Pecos County, the top of the lime series was found at shallower depths, which are listed with a discussion of the sequence of beds near the top of the lime, in the section on "Structural Geology."

MESOZOIC

The Paleozoic was an epoch of intermittent marine sedimentation to the south of the Fort Stockton region and possibly over it. However, the oldest beds reached by the drill near Fort Stockton are Permian. The Permian sea presumably retreated gradually, and there were local areas of desiccation and precipitation of the dissolved salts. After the deposition of the Permian in this region the sea withdrew, and the emerged land was denuded. The Triassic was apparently an epoch of non-marine deposits in this part of West Texas. Triassic red beds and sandstones with non-marine fossils outcrop along the eastern border of the Staked Plains, and these rocks occur near the Pecos to about the latitude of Fort Stockton; south of there they are unknown. The nearest marine Triassic is far to the west in the Antimonio region, N. W.

Sonora,[14] and to the south in Zacatecas (both Carnic).[15] No sediments ascribed to the Jurassic occur near Fort Stockton. The nearest marine Jurassic is in the Malone area.[16] Likewise beds of Eo-cretaceous (Neocomian, excluding Aptian) age are known in Trans-Pecos Texas only in the Malone-Quitman Mountains area. The presence of beds of the Trinity division in the Fort Stockton quadrangle is questionable. The basal Cretaceous sandstone east of the Pecos in the latitude of Pecos County has been called Trinity by various writers, but so far no diagnostic Trinity fossils have been recorded from it. Near Fort Stockton the Cretaceous sections begins with about 140 feet of sandstone and sand, the top part of which is probably of early Fredericksburg age.

The middle and probably most of the upper Cretaceous was a period of marine deposition in this region. In the Davis Mountains beds as high as the Taylor (Pierre, *Exogyra ponderosa)* occur. These were likely deposited over the Fort Stockton region, but have been entirely removed; whether higher Cretaceous beds, such as are represented by the non-marine or intermittently marine uppermost Cretaceous of the Chisos Mountains region, were ever deposited here is unknown. At any rate, no marine Tertiary is known from this region, and the Cretaceous was therefore a marine interlude between two long periods of emergence and denudation, Permian-Trinity, and Tertiary-Recent.

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[14]C. Burckhardt: Quelques remarques critiques sur l'ouvrage de M. W. Freudenberg, "Geologie von Mexico," Soc. Sci. Antonio, Alzate, 41, 1923, 185–196 (p. 189). Some of this material is in the United States National Museum. E. T. Dumble: Triassic coal and coke of Sonora, Mexico. GSA Bull., 11, 10–14, 1900. E. T. Dumble: Notes on the Geology of Sonora, Mexico, A.I.M.E. Trans., 29, 122–152, 1900.

[15]C. Burckhardt: La faune marine du Trias Supérieur de Zacatecas, Inst. Geol. Mex., Bol. 21, 1905.

[16]F. W. Cragin: Paleontology of the Malone Jurassic formation of Texas. U.S.G.S. Bull. 266, 1905. F. L. Kitchin: The so-called Malone Jurassic formation in Texas. Geol. Mag., LXIII, 454–469, 1926.

TRIASSIC

Pecos County lies near the southern limit of the Triassic beds as described by Cummins,[17] Drake,[18] Hoots,[19] and other authors. The Triassic was described by Cummins as Dockum beds from the type locality Dockum in western Dickens County, near the eastern scarp of the Staked Plains, and later was partitioned by Drake into three members: "a lower bed of sandy clay, which is from 10 to 150 feet thick; a central bed of sandstone, conglomerate, and some sandy clay, which is from 0 to 235 feet thick; an upper bed of sandy clay and some sandstone, which is from 0 to 300 feet thick."[20] Hoots considers that the Dockum group of the southeastern Llano Estacado is divisible into two formations, a lower one characterized by red clay and numerous beds of massive, gray, cross-bedded sandstone (maximum thickness, 275 feet), and an upper one consisting almost entirely of red clay (maximum thickness, 175 feet or more). The Triassic outcrop passes down the Pecos valley to about Red Point in southeastern Crane County, where it consists of light-colored, gray, red, or brown sandstone, with some red sandy clay and some conglomerate containing quartz pebbles. It outcrops at a few places in northern Pecos County, and is thought to be present in certain wells near Fort Stockton, which are listed below.

The following features are of variable and uncertain value for the sub-surface diagnosis of the Triassic in this region, but may be listed for reference.

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[17]Cummins, The Permian of Texas and its overlying beds. Geol. Surv. Texas, 1st Ann. Rept. pp. 189–190. 1890.

[18]Drake, Stratigraphy of the Triassic formation of northwest Texas. Geol. Surv. Texas, 3d Ann. Rept., pp. 229–247, 1892.

[19]Hoots, U. S. G. S., Bull. 780-B, 86–96, 1925.

[20]Drake, *ibid.*, pp. 230–231.

		Basal Cret.	Trias.	Upper Perm.
1	Echinoid spines	+	–	r or –
2	Foraminifera	+	–	r
3	Ostracoda	+	–	r
4	Chara seeds	+	–	– ?
5	Phosphate	– ?	p	r
6	Muscovite	?	p	r
7	Gravel	p	r	– ?
8	Red clay	r	+	+
9	Calcareous material	p	r	r
10	Sand	+	+	+

(r=rare; p=present in many samples.)

The existence of Triassic in the Fort Stockton section has not been positively proven. Hoots considers that in the southern portion of the outcrop lithology is the best guide to identification, and he mentions the prevalence of brown and green, cross-bedded sandstones, and in some places makes partitions so as to exclude red clays from the Cretaceous. Color distinction such as prevail in the Panhandle of Texas seem unreliable in the central Pecos Valley. The presence of phosphate or abundant muscovite is claimed to be of diagnostic value in this area, but distinctions based on extensive field observation on known Triassic sections from this region have not been published. Unios and vertebrate remains have been reported from outcrops of the Triassic, but the Pecos County wells have so far failed to yield diagnostic Triassic fossils.

The following Pecos County well samples occur near the top of the Red Beds series, and contain mica or phosphate:

Townsite well: mica, 530–534, 534–538, 626–630.

Oregon-Tex well: mica, 60–65, 80–90, 100–110, 200–210.

Macy 1 (Section 29, Block 10) : mica, 208–210.

Maul 1 (Section 89, Block OW) : phosphate at 405 (possibly Cretaceous).

CRETACEOUS

Only the Lower Cretaceous (Comanchean) occurs in the Fort Stockton quadrangle; the section extends from Fredericksburg (or high Trinity?) to the Mainstreet limestone.

These rocks are of the northern facies. The contrast between the northern and the southern facies, both in the Fredericksburg and in the Washita division, is as clear in Trans-Pecos Texas as in Central Texas. The Fredericksburg of the southern facies is mainly a massive, thick limestone, poor in ammonites and at many levels rich in rudistids. It is mostly pure limestone; it largely lacks shale; many levels carry chert. Passing northwards and nearer shore, it thins and becomes more argillaceous and softer. Ammonite, echinoid and oyster beds are prominent; rudistids are restricted to certain harder layers. The southern facies of the Washita division consists of three formations, a basal thin limestone (Georgetown) which at many places has the lithology of the underlying Edwards limestone and is with difficulty distinguished from it (Devil's River limestone), a middle shale (Del Rio), and an upper hard, sparsely fossiliferous limestone (Buda). On passing northward the Georgetown thickens and splits into the alternate marls and limestones of the north Texas section; the Del Rio and the Buda thin. The rudistids of the Washita persist only in the harder ledges, here called cap rocks, which are interbedded with softer strata, resist erosion, and make the platforms and caps of mesas and cuestas. In the Fort Stockton region there are three: Lower Cap Rock, capping the Fredericksburg platforms; Middle Cap Rock (Denton), and Upper Cap Rock (Main Street). The "single" mesas like Seven Mile Mesa are capped by the Middle Cap Rock; "double" mesas like University Mesa and Five Mile Mesa are capped by the Upper Cap Rock. These cap rocks persist for considerable distances in the northern facies. The line between the two facies has not been closely studied, but it lies near the Southern Pacific Railway as far east as Strobel, and thence runs north of east near Gaptank and crosses the Pecos north of Sheffield; over part of this distance it approximates the southern margin of the salt basin. The Main Street limestone is the highest formation exposed in the quadrangle; the higher Washita and Upper Cretaceous formations outcrop west of Hovey.

In this quadrangle the basal Cretaceous sand is about 140 feet thick; the Fredericksburg limestone and marl about 208 feet thick; and the Washita exposed about 245 feet thick; total Cretaceous about 593 feet.

THICKNESS OF CRETACEOUS BEDS NEAR FORT STOCKTON

	Univ. Mesa	12-Mile Mesa
Above Upper Cap Rock (exposed)	20	25*
Top of Mid Cap Rock to top of Upper Cap Rock	106.8	113.5
Top of *Desmoceras* zone to top of Mid Cap Rock	105	61.2
Top of Brown *(Trigonia)* limestone to top of *Desmoceras* zone	79.4	76.5
Top of basal Cretaceous sandstone to top of Brown limestone	141.5*	141.5
Basal Cretaceous Sandstone (exposed)	53.8	50*
Total Cretaceous (exposed)	506.8	467.7

It seems unnecessary to use new formation names in this region, because the Cretaceous formations here are of the same facies as in North-Central Texas and have zone fossils in common. Identical formation boundaries may be located with the following exceptions: the top of the Fredericksburg is more clayey at Fort Stockton, the Denton is a limestone instead of a clay, and the Pawpaw has not been identified with certainty. The various formations in the Fredericksburg limestone have not been clearly delimited, but the limestone appears to be of about the same age as the Goodland in the Fort Worth region. In using the above thicknesses it should be noted that the weathering of the cap rocks is variable and the intervals between them variable. However, no such difficulty is encountered if the fossil zones are strictly followed. For example, the most resistant ledge of the Mid Cap is at some places above the *Pyrina* zone, at other places beneath it, but the interval from *Pyrina* to *Desmoceras* is rather constant.

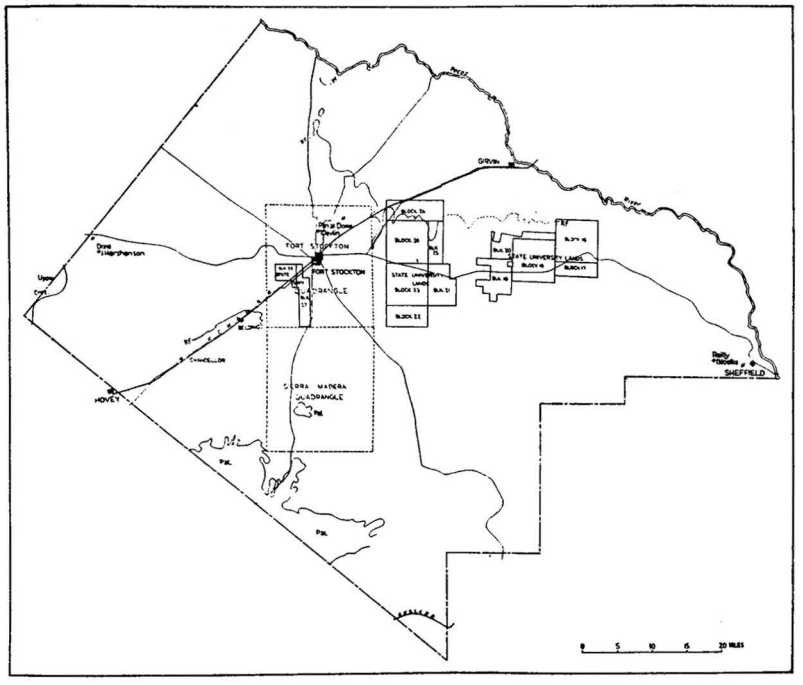

Fig. 3. Map of Pecos County, showing outcrops of Basal Comanchean sand (Kf), and Upper Cretaceous, and Paleozoic, and location of University lands and of wells shown in Fig. 2.

BASAL CRETACEOUS SANDSTONE

(Fredericksburg or ?Trinity)

Character: The Cretaceous begins near Fort Stockton with a ferruginous vari-colored sandstone, about 140 feet thick, which unconformably overlies Permian or Triassic red beds. This formation is a portion of the northward progressive overlap of the Cretaceous beds on the older land; farther south in the east rim of the Marathon dome and in the Sierra del Carmen, still older Cretaceous (Trinity) overlies the old land. At the outcrop northeast of Fort Stockton, in University Block 26, the basal Cretaceous formation is medium to thin-bedded, locally cross-bedded, ferruginous or vari-colored sandstone, at most places friable

and poorly cemented. The grains are coarse to medium-sized, and are mostly round or sub-round. Below the upper 50 feet there are scattered fine and coarse conglomerates with well rounded igneous and other pebbles. In both the base and the top of the formation there are light-colored sandstones with small evenly scattered specks of iron stain. Some ferruginous sandstones are well indurated, and other thin strata consist of loose pack sand. Ripple marks were seen in the base of the sandstone in H. & G. N., Block 8.

Outcrop: The formation outcrops at only one place in the Fort Stockton quadrangle northwest of Seven Mile Mesa. Nearly a complete section is seen at the lake east of Santa Rosa Spring (H. & G. N. R. R., Block 8). From the southeast corner of this block, near the Ink Ranch, the main outcrop passes irregularly southeastward as a narrow band, near the Devlin Ranch and the old shallow oil field (T. & St. L., Block 140), crosses the Orient Railway and the Girvin road about eight miles northeast of Fort Stockton, makes a long narrow hairpin reëntrant east of Seven Mile Mesa, and another west of University Mesa in University Block 24, Section 32, and thence passes eastward along the north base of a long irregular line of south dipping limestone cuestas to a point on the Pecos downstream from Girvin. Only the top of the sandstone is exposed at most places, the base passing northwards under a large alluvial flat. However, at some places in this flat and near the sand outcrop, the underlying beds must be very near the surface.

Another considerable outcrop of basal sandstone occurs just off the southwest corner of the Fort Stockton sheet at the west end of Twelve Mile Mesa, and thence southwest along the west side of the Orient Railway, past the base of Triple Peak (T.P., Block 3) and to within a mile of Chancellor, where there is a small quarry in this stone. Here the sandstone has reddish and brown color laminations, and superficially resembles the vari-colored, banded Eagle Ford of the Boquillas flag facies in Terrell County.

Other areas of basal sandstone are reported from the north corner of Pecos County, near Triassic outcrops. The exposures at Girvin and along the Pecos have been detailed by Liddle and Prettyman, and others. This formation occurs in wells within its outcrop throughout this region, and is the most valuable marker known in the Cretaceous. For its occurrence in water wells see pp. 79–80, 91–92.

Fossils and Age: No large fossils have been found in the base of the formation. At all places where the top was examined, it and the base of the overlying limestone contain a zone of *Exogyra weatherfordensis* Cragin and *Exogyra texana,* var. (with flared valves and spinose imbrications). These fossils are not absolutely diagnostic, but indicate Fredericksburg age. They occur at University Mesa, Twelve Mile Mesa, at a locality two and one-half miles west of Rankin, and elsewhere. The base of the limestone contains a considerable assortment of *Lunatia, Tylostoma,* other gastropods and pelecypods, and *Heteraster.* Some of these basal layers in the limestone are marly, and might correspond to what various writers call Walnut in the Pecos River region, but the fossils at hand from near Fort Stockton are insufficient to identify the level with the Walnut of Central Texas. A considerable search in the limestone and sandstone failed to reveal such typical Trinity fossils as *Orbitolina texana* (Roemer) and *Porocystis globularis* (Giebel).[21]

Thickness and depth of basal sand are tabulated under "Structural Geology."

Basalmost Cretaceous: In some wells in Pecos County, beneath the "Basement Sands" or else a downward continuation of them, is a series of sandy limestones and clays, which rest on the underlying Red Beds. These have been recorded from the following wells:

Maull 1 (Batchler 1), Section 89, Block OW.
Southwestern Life 1 (Buell and Hagan), Section 89, Block OW.
? Thomas 1 (Trans-Pecos Oil Co. 5), Section 6, Block 114.

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[21]Erroneously called *Porocystis pruniformis.* There are several species of this genus in the Comanchean.

Kokernot 1 (Twin Cities), Section 139, Block 10, Brewster County.

? Noelke 1 (Reilly-Texas Acreage Co.), Section 4, Block 193. Belding well.

In the lowermost Cretaceous of Maull No. 1, and of Buell and Hagan's Southwestern Life-Batchler No. 1, both on Section 89, Block OW, about nine miles west of Fort Stockton, charophyte oogonia were found at the depths indicated below. Some of these fruits belong apparently to two species, *Chara texensis* and *Chara brewsterensis,* described in 1925 by Groves[22] from "an oil-well, at a depth of 3,375 feet, in Brewster County, in a stratum of Cretaceous age, the horizon of which is uncertain." The Bureau of Economic Geology has recorded *Chara* fruits from the Twin City Oil and Gas Company's Kokernot No. 1 well, near Hovey, Brewster County, at depths of between 3,100 and 3,511 feet, in strata of probable Trinity age. Possibly this well is the type locality of the fruits described by Groves. The ranges of these fruits are not yet worked out, and in the absence of extensive special studies, they could not be claimed to diagnose their horizon as Trinity division. However, in the Kokernot well at 3265–3270, "*Orbitolina* and *Chara* seed" are recorded, and at 3375 we have the notation "aspect of Trinity sands." The following are records of *Chara* fruits from the wells above mentioned:

Kokernot 1: Several varieties of *Chara* seeds, and a pod-like body about one mm. in length and one-eighth mm. in diameter were noted. The covering of this pod is fluted. Evidently Comanchean.....3100

Limestone, some quartz sand and pyrite. In the washed material were noted two pieces of *Orbitolina,* echinoid spines and *Chara* seeds 3265–3270

Quartz grains, some pyrite and gypsum. The coarser material contains a few ostracods and numerous barrel and disk-shaped *Chara* seeds, the former predominating. *Pulvinulina* noted. Aspect of Trinity sands....3375

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[22]James Groves: Fossil charophyte fruits from Texas, Am. Jour. Sci. (5), X, 12–14, 3 figs., 1925.

Gray and brownish limestone, clear calcite, and quartz sand grains. A few crystals of pyrite noted. *Chara* seeds present 3400–3485

Clear calcite and pieces of brownish limestone; pyrite and a few quartz sand grains noted. Many *Chara* seeds present 3490–3498

Gray and brownish limestone, clear calcite, and quartz sand grains. A few *Chara* seeds noted 3500–3511

Maull No. 1: Red calcareous clay, in which small pebbles occur in lumps of purplish-red clay; quartz grains, pyrite, calcite; sample gives test for phosphate; (No *Chara* recorded) 405

Clay, some quartz grains, much pyrite. In the sample was found a single spherical grain, evidently calcareous, ornamented with shallow grooves, some of which radiate irregularly from a point on the surface. This sphere measures one mm. in diameter. It is not perfectly spherical; some of the grooves run obliquely, suggesting a resemblance to a *Chara* seed. The material of which it is made has an amber color, and appears to be quite solid 412

Light gray, calcareous clay; quartz sand, chert grains, pyrite, light gray limestone. Several of the bodies resembling *Chara* fruits and described in the sample from 412 feet are present. An ornate ostracod, and echinoid spines and tissue are present 444

Light gray, calcareous clay; gray and white limestone, quartz sand, pyrite. Several of the organic bodies described in the sample from 412 feet were noted in this sample. An echinoid spine is present. Probably Cretaceous 446

Southwestern Life (Batchler) No. 1: In this well there appears to be a group of strata (approximately at 520–680 feet) which is not represented in wells near Fort Stockton, but which may correspond to similar strata in the Thomas 1 (=Trans-Pecos 5) well.

645–655: Quartz sand and grayish calcareous clay; 2 larger and 1 smaller *Chara* seeds (not Groves' species). 655–665; Quartz sand in calcareous cement; 9 larger spherical and 2 smaller flattened *Chara* seeds (not Groves' species). 685–695: Same lithology; one spherical *Chara* seed. 690–695: Reddish shale and quartz sand with calcareous cement; 5 spherical *Chara* seeds, one with faint ridges. 705–710: Subangular to subrounded, clear quartz grains with white, calcareous cement. At least 90 per cent of the grains is quartz; there are small amounts of calcite, decomposed feldspar, muscovite, pyrite, zircon, magnetite (or ilmenite), and other detrital minerals.

Many *Chara* seeds. 710–715: Same lithology; 6 spherical *Chara* seeds seen. 750–755: Bluish and gray calcareous shale with subangular quartz particles; some pyrite; about 20 *Chara* seeds seen. 810–820: Reddish and amber-colored subangular to subrounded quartz grains with calcareous cement; no *Chara* noted. 795–810, 830–835, 845–850; same lithology; no *Chara* noted.

Thomas 1 (Trans-Pecos 5): *Chara* was not found in the samples 260–652 from this well, but the basal Cretaceous is unusually thick, and its lower part corresponds lithologically to beds which elsewhere carry this fossil.

Belding well: Two *Chara* seeds were reported in a sample of gray sand at 315 feet, with pieces of lignite, pyrite and grains of concretionary white limestone. This sample was identified as Comanchean by the Bureau of Economic Geology. The top of the Basement Sands is seen in the west end of Twelve Mile Mesa at an elevation considerably above Belding Station. If the Comanchean (with *Chara)* goes to at least 315 feet depth in the Belding well, the easiest explanation is that this well, like those cited above, contains limestone and other Comanchean rocks beneath the Basement Sands; otherwise special structural conditions would be necessary to explain the presence of the "Trinity" sand at such depth.

Oysters in Noelke (Reilly) well: Dr. J. A. Udden has recorded from this well, one and one-half miles west of Sheffield, an unusual association of oysters with ostracods, lignite and anhydrite, extending over the depths 527–1090. He supposes that the Mesozoic continues down to 1090 feet in this well. The records follow:

Dark and light gray anhydrite; oysters	527–595
Sandstone and salt; oysters; lignite	590–820
Anhydrite, shale, limestone; shells and ostracods	590–820
Anhydrite and limestone; oysters ("Mesozoic")	850
Anhydrite; oysters	855–860
Sand or sandstone; oysters?; ostracods	1055–1090

At first sight one might surmise that the oysters are cavings from a higher level into the lower beds containing anhydrite, but if this is not true, a local downward extension of the Mesozoic is possible. The exact age of these beds is doubtful.

Locally at least in Pecos County, Permian highs may be associated with thin Red Beds, in places where the latter were denuded and removed in pre-Comanchean times. Locally also, thin Red Beds are associated with thicker basal

Comanchean, as in Section 89–OW. It is possible that the Comanchean sea invaded erosional troughs in the Red Beds and deposited over limited areas beds (early Fredericksburg or even Trinity) which are older than those generally found near Fort Stockton. There are indications of considerable variation in thickness of the basal Comanchean in well logs near Fort Stockton, but without samples from the earlier wells it is unknown whether the *Chara* beds already mentioned are represented or not.

FREDERICKSBURG DIVISION

The following rocks are referred to this division:

		Feet
3.	Clay (Kiamichi and ?post-Kiamichi)	66.5
2.	Clay (Goodland)	50
1.	Limestone (Comanche Peak and ?Walnut)	91.5
	Total	208

The basal limestone probably contains the equivalents, if any, of the Comanche Peak and Walnut formations in this region. The marly layer is the "yellow horizon" used by local geologists. This soft Fredericksburg is extensively exposed at the base of the scarps between Fort Stockton and Sheffield, and it occurs along the El Paso road near Barilla Creek and on the Alpine-Fort Stockton road seventeen miles from Alpine. At all these places it underlies the bench formed by the basal *Desmoceras-trinodosa* limestone of the Duck Creek. Both the marl and the limestone are very fossiliferous; the marl contains great oyster beds, and the limestone is rich in ammonites. This zone occurs at the base of all mesas in the Fort Stockton quadrangle, and is the horizon of the classic type locality of Conrad at Leon Springs.

COMANCHE PEAK LIMESTONE

Character: Most of this limestone is soft and rather nodular, thin-bedded and somewhat argillaceous, grayish interiorly and weathering white. There are marly layers especially near the base, and in the middle and upper part

some harder rudistid-bearing layers which form mesa platforms and support extensive ocotillo thickets. These hard layers increase in prominence in eastern Pecos County. North of University Mesa may be seen south-dipping alternate soft layers forming depressions and hard layers forming cuestas. These rocks are superficially indurated, but interiorly they are soft and consist of fine sub-rounded rock particles in a calcareous matrix. They exhibit schratten-weathering and etched potholes.

Outcrop: Within the quadrangle, at the northwest end of Seven Mile Mesa, west end of Twelve Mile Mesa. Elsewhere, Sheffield road, near Tunas Spring and eastward; north of University Mesa; Grandfalls road; Sierra Madera.

Fossils and Age: In the base of the limestone, *Exogyra weatherfordensis* and *Exogyra texana* var. are common. Just above the base is a soft layer with echinoids *(Heteraster, Holectypus, Goniopygus)* and gastropod and pelecypod casts. The middle and top of the limestone contain layers of rudistids *(Eoradiolites?, Caprinula)*, which become more abundant south and east of Fort Stockton. On the Sheffield road, twenty-five miles east of Fort Stockton, and on the Marathon road near Gaptank, some limestone ledges expose masses of weathered rudistids. This limestone is considered equivalent to a part of the Goodland of North-Central Texas.

Thickness: At University Mesa and at Twelve Mile Mesa, about 91.5 feet.

FREDERICKSBURG CLAY

Character: Above the limestone is a brown, fossiliferous, calcareous clay, which extends up to a prominent, hard thin ferruginous limestone. Above this limestone layer is more clay, which extends upwards to the base of the Duck Creek limestone. The clay under the brown limestone seam is interspersed with thin limestone seams at scattered intervals. It mostly is a light yellow or brownish, iron-stained calcareous clay weathering yellowish-brown; the thin limestone bands are soft and gray, but near the top there are some thin beds of soft ferruginous limestone.

Outcrop: The brown limestone makes a prominent bench at the west end of Twelve Mile Mesa, on the east and west points of Seven Mile Mesa, on the north side of University Mesa, and in the valleys along the Sheffield road and very generally in eastern Pecos County. The clay makes a variable outcrop under it, depending on the height above the alluvial slope. The alluvium conceals the clay outcrops at most places in the Fort Stockton quadrangle.

Fossils and Age: About twenty feet below the top there is a prominent echinoid zone *(Heteraster, Pliotoxaster, Salenia)*. Several species of *Engonoceras* are found. Just under the brown limestone at the top is a thin zone of a distinctive *Oxytropidoceras* n. sp., with numerous fine ribs. This clay is probably to be correlated with some part of the Goodland limestone, but its exact correlation awaits a more detailed study of the ammonite succession in Central Texas.

FOSSILS OF MIDDLE FREDERICKSBURG CLAY

Oxytropidoceras n. sp. 1
Oxytropidoceras supani (Lasswitz)
Oxytropidoceras acutocarinatum (Shumard)
Oxytropidoceras trinitense (Gabb)
Oxytropidoceras bravoense (Böse)
Oxytropidoceras kiowanum (Twenhofel)
Oxytropidoceras belknapi (Marcou)
Oxytropidoceras cf. chihuahuense (Böse)
Engonoceras sp.
Pliotoxaster sp.
Heteraster sp.
Gryphea marcoui Hill and Vaughan
Gryphea sp.
Alectryonia sp. 1
Alectryonia sp. 2
Cyprimeria sp.
Nucula sp.
Tapes sp.
Trigonia sp.
Protocardia sp.
Tylostoma sp.
Amauropsis? sp.
Turritella sp.
Natica sp.

Thickness: About 50 feet.

KIAMICHI CLAY

Character: Above the brown limestone is the first appearance of *Gryphea navia* Hall, and the Kiamichi is supposed to begin at this point. The interval from the brown limestone to the base of the Duck Creek limestone is 66.4 feet at University Mesa, but *Gryphea navia* occurs only in the basal half of this, the top part lacking it and being characterized by a great development of the local species *Gryphea tucumcari* Marcou. In addition, in the top part the ammonite development *(Hamites, Elobiceras, Pervinquieria)* of the overlying Duck Creek limestone commences. It is therefore still uncertain to what extent the upper part of the clay is represented in Central Texas localities, as the type Duck Creek near Denison, but it is certain that the basal part represents the Kiamichi. The Kiamichi is here an iron-stained grayish to light yellow-brown calcareous clay weathering brownish, with a few scattered soft limestone seams.

Outcrop: In the quadrangle the Kiamichi outcrops at the foot of all Duck Creek scarps; a list of these *(Desmoceras* localities) is given on page 78. The complete section is exposed at University, Seven and Twelve Mile Mesas, and at a round butte north of the Sheffield road in University Block 18, 33 miles east of Fort Stockton, where a fine detailed section is seen. The top is exposed at Five Mile Mesa, Comanche and Leon Springs, Round Mountain, Triple Peak, and numerous other places. It is well exposed on the Fort Stockton road 17 miles northeast of Alpine, and at numerous localities in eastern Pecos County. About two miles east of Five Mile Mesa (on Section 18, Block 118) there is a 50-foot open hole with abundant Kiamichi fossils *(Exogyra texana, Gryphea corrugata).*

Fossils and Age: The basal part of this clay has *Gryphea navia* Hall, a marker for the Kiamichi in North-Central Texas; just on top of the brown limestone is a shell bed of these oysters. Above this are great quantities of *Gryphea corrugata* and a little higher *G. tucumcari.*

The highest *Oxytropidoceras (supani, trinitense* and n. spp.) found in the section are at this level. At a higher

level, in the top part of the clay are the first *Pervinquieria.* The junction between these two genera may be considered the line between the Fredericksburg and Washita divisions. In the same beds with the earliest species of *Pervinquieria* is a great development of *"Elobiceras,"* which does not survive into the overlying Duck Creek limestone, and of *"Hamites,"* which does. These ammonites cannot be discussed here except to point out that the new species in this fauna have a very striking similarity with the species of the same genera found in Angola, the Elobi Islands and the west coast of Africa, and that each of the species from Fort Stockton can be parallelled by a closely similar species from that region.

FOSSILS OF KIAMICHI AND ?POST-KIAMICHI BEDS

Pervinquieria n. sp. (aff. orientalis Kossmat)
Pervinquieria n. sp. al
"Elobiceras" n. sp. s (form of orientalis Kossmat, var.)
"Elobiceras" serratescens Cragin 1893 (aff. angustum Spath)
"Elobiceras" n. sp. l (aff. flexuicostatum Spath)
"Elobiceras" n. sp. ap (aff. arietiforme Spath)
"Elobiceras" n. sp. 4 (aff. arietiforme Spath)
"Hamites" fremonti Marcou
"Hamites" comanchensis A. & W.
"Anisoceras" n. sp.
Pliotoxaster sp.
Heteraster sp.
Salenia sp.
Holectypus sp.
Kingena wacoensis (Roemer)
Gryphea navia Hall
Gryphea tucumcari Marcou
Gryphea corrugata H. & V.
Alectryonia quadriplicata (Shum.)
Alectryonia sp.
Pecten subalpinus Böse.

The brown limestone at the base of the clay is a thin, indurated, ferruginous, fossiliferous limestone containing casts of *Trigonia, Protocardia, Nucula* and other pelecypods.

Thickness: The total clay above the brown limestone and below the base of the *Desmoceras-trinodosa* limestone of the Duck Creek is about 66.5 feet thick.

WASHITA DIVISION

DUCK CREEK LIMESTONE

Character: The Washita begins with 13 feet of Duck Creek limestone which contains an "explosive" development of ammonites of the genus (or sub-genus) *Pervinquieria.* This zone is widespread in the northern facies from Denison to El Paso, and near Fort Stockton is rich in both species and individuals. It thus forms one of the most striking paleontological features of the Washita division. In this section the *"Elobiceras"* zone lies below the *Hamites* zone and only slightly overlaps it; *Elobiceras* precedes *Desmoceras* and *Pervinquieria* (except two or three species) in the succession; and *Oxytropidoceras* is still earlier and does not overlap any of the other zones. This scheme seems to be somewhat modified at Denison, but the exact details of that section are not clear. At Fort Stockton the Duck Creek appears to be conformable on the underlying clay. The basal 13 feet of Duck Creek limestone is a soft, chalky, nodular, whitish, argillaceous limestone rich in fossils; it is succeeded by alternations of similar limestone and very calcareous clay which are less fossiliferous. The basal ledge capping the Kiamichi shale slope makes a projecting ledge in cliff faces and a platform where the overlying beds are removed.

Outcrop: In the quadrangle, at Five, Seven, and Twelve Mile Mesas, and many other exposures. The best localities are University Mesa and Thirty-three Mile Butte (1033). Conrad's classic Leon Springs locality is at this horizon. Some *Desmoceras* localities are listed on page 78.

Fossils and Age: It is not practicable here to discuss the rank to be assigned to *Pervinquieria* and *Oxytropidoceras;* Diener places them as sub-genera under *Schloenbachia,* but Spath, Stieler and others treat them as genera. *Oxytropidoceras* is limited to the Fredericksburg division and Kiamichi clay, *Pervinquieria* to the Washita division, and *Mortoniceras* to the Upper Cretaceous.

Oxytropidoceras supani Lasswitz 1904 is usually called *belknapi.* It has numerous closely spaced, round-topped,

undivided ribs, and many individuals reach a large size. Dr. Stanton has pointed out that Marcou's *Ammonites gibbonianus* Lea is *trinitensis* Gabb; the ventral ends of its ribs are excavated on the side toward the aperture Boese's Schl. *chihuahuensis* is possibly a synonym of it. A species with numerous low ribs is confined to the Upper Fredericksburg; and there are other undescribed species in the Cretaceous of Texas.

Pervinquieria J. Boehm 1910 replaces the names *Inflaticeras* Stieler 1920 and *Subschloenbachia* Spath 1921, the genotype being *Ammonites inflatus* Sowerby.[23] *P. nodosa* Boese is near *P. leonensis* Conrad 1857. The type locality of *leonensis* is Leon Springs, Pecos County and its horizon Duck Creek; it is therefore not an index fossil of the Fort Worth limestone, and is rare if present at all in that formation. The common Fort Worth limestone species is *P. maxima* Lasswitz 1904. An abundant Duck Creek species, hitherto unrecorded, is *P. shumardi* Marcou. *P. equidistans* Cragin 1893 is near *trinodosa* Boese 1906. A common Duck Creek "Elobiceras" was described as *serratescens* Cragin 1893. Several other species not recorded since their description are here placed stratigraphically.

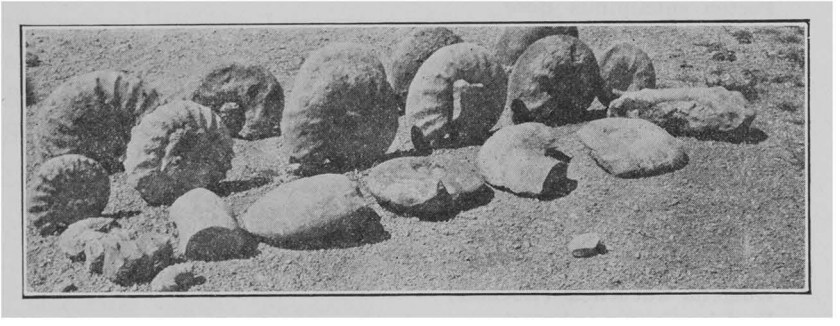

Fig. 4. Ammonites of basal Duck Creek Limestone, *Desmoceras* (right) and *Pervinquieria* (left).

At the base of the Duck Creek is a prominent zone of the echinoid *Macraster*.

[23]Dr. Spath kindly called my attention to this reference.

FOSSILS OF DUCK CREEK LIMESTONE

Hamites comanchensis A. & W.
Hamites fremonti Marcou
Hamites spp.
Anisoceras sp. ?
Desmoceras brazoense (Shumard)
Desmoceras laevicaniculatus (Roemer)
Desmoceras sp.
Pervinquieria leonensis (Conrad)
Pervinquieria shumardi (Marcou)
Pervinquieria ("Elobiceras") serratescens (Cragin)
Pervinquieria equidistans (Cragin) P. aff. trinodosa (Böse)
Pervinquieria austinensis (Roemer)
Pervinquieria kiliani (Lasswitz)
Pervinquieria minima (Lasswitz)
Pervinquieria burckhardti (Böse)
Pervinquieria whitei (Böse)
Pervinquieria n. spp. (c, p, st)
Pervinquieria n. sp. 1 (aff. stolizkai Spath)
Pervinquieria aguilerae Böse (at 1026)
Ostrea sp.
Alectryonia sp. 1
Alectryonia sp. 2
Gryphea corrugata H. & V.
Gryphea tucumcari Marcou
Pecten subalpinus Böse
Cyprimeria
Lima
Trigonia
Gervilliopsis sp.
Alectryonia aff. carinata (Lam)
Pliotoxaster sp.
Heteraster sp.
Macraster sp.
Pedinopsis aff. symmetrica
Kingena wacoensis (Roemer)
Pyritic micromorphs

Thickness: At University Mesa the Duck Creek formation is 47.5 feet thick; at Thirty-three Mile Butte (Loc. 1033) about 39.1 feet. The basal ammonite-rich layer is about 13 to 15 feet thick at most places.

FORT WORTH LIMESTONE

Character: The beds referred to the Fort Worth limestone are alternate thin-bedded soft limestone and calcareous clay, and have about the same lithology and appearance as the underlying Duck Creek limestone but with more limestone and less clay. They are directly overlain by the Middle Cap Rock, a massive rudistid-bearing ledge. Near the top there is at some localities a thin, faint zone of chert nodules.

Outcrop: This limestone is more easily weathered than the Middle Cap Rock and everywhere forms a cliff face under that ledge. It has one or two thin more resistant ledges which at some places form small benches. In the quadrangle, it outcrops in the three mesas, and in small buttes and cuestas along the Grandfalls and Buenavista roads north of the irrigated lands. At University Mesa and in eastern Pecos County it is well exposed.

Fossils: The top of this limestone just beneath the cap rock has a persistent zone of several species of *Macraster (elegans, aguilerae,* etc.). Throughout the formation *Pervinquieria maxima* Lasswitz is found. These levels may be studied on the hill slope between the head of Leon Springs Reservoir and the Southwestern Life No. 1 Well (Block OW, Section 89).

FOSSILS OF THE FORT WORTH LIMESTONE

Pervinquieria maxima (Lasswitz)
Pervinquieria spp.
Macraster elegans (Shumard)
Macraster aguilerae (Böse).
Macraster ? sp.
Pliotoxaster sp.
Gryphea washitaensis Hill
Pecten subalpinus Böse.

Thickness: At University Mesa, 32 feet; it is nearly the same elsewhere.

MIDDLE CAP ROCK

Character: This rock is a group of more resistant massive or medium bedded, rather pure limestones, some of them rudistid-bearing and some not. Their resistance to weathering is variable, and at different places different ledges are most prominent; therefore intervals taken on a prominent ledge are less reliable than those taken on fossil zones. This rock caps Seven Mile Mesa, forms the middle cap of Five Mile Mesa, and is imbedded in the side of Twelve Mile Mesa. It can be studied to advantage at University Mesa (Univ. Block 24, Sections 33–34) and in eastern Pecos County. The rudistid rock is a white, pure limestone composed of fine calcareous particles and shell detritus with a calcareous cement, soft interiorly and superficially indurated.

Outcrop: In all prominent mesas of the region; cuestas north of the irrigated lands; along Fort Stockton-Sheffield road.

Fossils and Age: This rock is of approximately Denton age, because (a) it is underlain by a normal thickness of Fort Worth limestone, (b) in its top is a layer of *Alectryonia* aff. *carinata* followed by probable Weno fossils, (c) it contains an assortment of echinoids which at Kent and El Paso are probably Denton and occur in the same sequence as at Fort Stockton. The rudistids of the Mid Cap have not been intensively studied, but are evidently distinctive of this horizon.

FOSSILS OF MIDDLE CAP ROCK

Pyrina inaudita Boese
Holectypus limitis Boese
Heteraster sp.
Caprinula n. sp.
Caprina sp?
Chondrodonta n. sp.
Pecten subalpinus Böse
Compound corals
Nerinea

Thickness: The amount of projecting strata above the *Pyrina* zone is generally from 20 to 40 feet. On some mesa faces this weathers to a smooth steep wall with no platform. Where higher strata are removed, it forms benches and is weathered down near its margin.

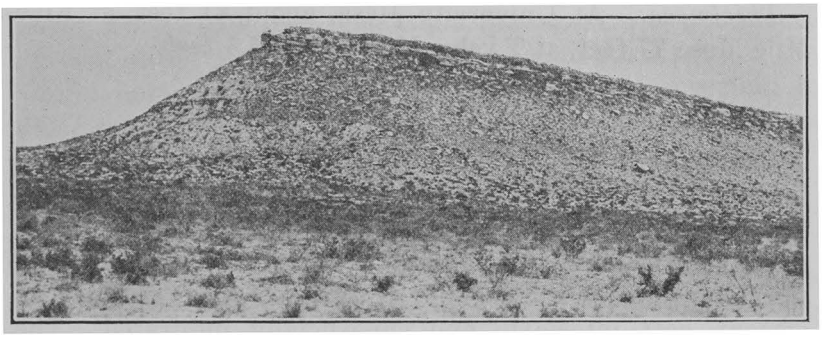

Fig. 5. Middle Cap Rock. West point of Seven Mile Mesa

WENO FORMATION

Character: This series of chalky limestones and calcareous clays is softer than the Mid and Upper Cap Rocks, and forms retreating mesa slopes between them. Near its top there is a conspicuous zone of nodular and platy chert, which weathers superficially to a deep red-brown color and is an important marker in the region. It is seen to advantage between the two cap rocks on the southeast extension of University Mesa and at Rock Quarry Hill 3.3 miles west of Fort Stockton, where weathered fragments cover the surface.

Fossils and Age: The strata between the two cap rocks contain near the base *Alectryonia* aff. *carinata* and Upper Washita fossils. Near the middle there is a zone of a small rudistid, *Toucasia* n. sp. About 15 feet below the top is a horizon of *"Nodosaria" texana* Conrad.[24] Ammonites are rare, and among them is probably the highest *Pervinquieria* in the section. This level is probably Weno; the Pawpaw with its characteristic zone fossil *Neokentroceras worthense* (Adkins) was not located.

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[24]This foraminiferan is arenaceous and has a multiple aperture. It does not even belong to the same family as *Nodosaria*, and is a new genus somewhat like *Cribrogenerina*. In the northern facies (Fort Stockton, El Paso, north-central Texas) its level is in the Weno-Pawpaw, but in the southern facies its principal level is in the Del Rio. It occurs also in the Trinity in the Solitario; there may be several species.

Thickness: At University Mesa, about 81 feet, at Five Mile Mesa 77 feet, at Twelve Mile Mesa 75.5 feet.

UPPER CAP ROCK

Character: This prominent, resistant rudistid-coral limestone caps the highest mesas and is the youngest Cretaceous of the Fort Stockton area. Lithologically it is similar to the other two rudistid horizons: a coarse-grained, pure limestone with organic fragments and a calcareous cement, soft interiorly and superficially indurated. The rudistids, sponges and corals weather out to projecting iron-stained masses, become disengaged and are strewn over the mesa tops. The reef types of molluscs abound, very corrugated Pectens as in Central Texas and Portugal, *Actaeonella, Nerinea* and *Cerithium.* Compound corals and sponges are common.

Outcrop: University Mesa, Five Mile Mesa, Rock Quarry Hill.

Fossils and Age: Exogyra arietina was found in this level at Kent. The rudistids near Fort Stockton include several new species of *Caprinula,* other caprinids, *Eoradiolites, Biradiolites(?), Toucasia, Monopleura* and *(?)Requienia.* This forms a distinct assemblage which cannot be confused with any other rock in the region. Its age is provisionally put as Mainstreet. This is the highest visible cap rock, and the next higher beds are found west of Hovey near the margin of the Upper Cretaceous.

FOSSILS OF THE UPPER CAP ROCK

Eoradiolites ? sp.
Caprina sp.
Monopleura sp.
Toucasia sp.
Actaeonella sp.
Nerinea sp.
Cerithium sp.

Thickness: About 15–40 feet remain on the tops of the highest mesas.

Beds above Upper Cap Rock: Near Sheffield the upper cap rock is continued as medium-bedded limestones to a thickness of 100 feet or more. Probably a small and

variable basal part of these beds occur on certain mesas near Fort Stockton. The Buda limestone was not identified at either Fort Stockton or Sheffield. At a point a few miles north of Comstock the Buda is directly overlain by Eagle Ford flags; this is the situation also at the north end of the Davis Mountains.

FOSSIL ZONES IN THE CRETACEOUS

In Central Texas the transitions between the northern and the southern Cretaceous sections have been considerably studied and are fairly well known. In that region the Trinity division overlaps northwards and westwards onto the old land, and its section is therefore fuller and generally thicker to the south and east. The Fredericksburg division is thicker to the south, where there exists a great development of the rudistid reef limestone facies; to the north certain levels are marly or sandy, and the rudistids persist northwards at only a few thin horizons, which are interfingered with non-rudistid-bearing beds. In South-Central Texas the Washita division is thinner and typically consists of three formations (Georgetown, Del Rio, Buda); to the north the Georgetown thickens and is composed of alternate marl and limestone formations, the Del Rio persists relatively unchanged, and the Buda is thin or absent.

In Trans-Pecos Texas there are much the same distinctions between the northern and the southern sections of the Comanchean. The similarities between the northern sections and those between Waco and Denison are so striking that it is justifiable to speak of a *Northern Facies,* which extends from North-Central Texas to northern Trans-Pecos Texas, and along its course presents very similar successions of rock formations and of zone fossils. Detailed study so far has emphasized more the differences between the northern and southern facies, and neglected the widespread and striking similarities within these facies. In Trans-Pecos Texas at most places the southern section of the Comanchean consists of the same formations as in Central Texas and has to a large extent the same fossil zones. There

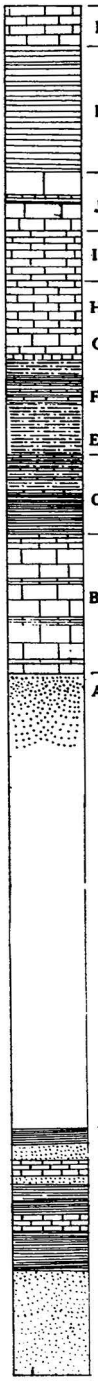

Fig. 6. Section of Cretaceous rocks near Fort Stockton, Texas. Scale, 1 inch = 130 feet.

L. Upper Cap Rock (Main Street). Massive limestone, superficially indurated, with schratten-weathering and etched potholes. Fossils: *Actæonella, Nerinea,* sponges, corals, and rudistids. Thickness, about 25 ft.

K. Weno. Thin bedded alternating limestone and marl. Zone of *"Nodosaria" texana* 15 ft. below top; zone of *Toucasia* n, sp, near middle. About 81 ft.

J. Middle Cap Rock (Denton). Massive limestone, the upper part rudistid-bearing. Rudistids, *Chondrodonta* n. sp., *Pyrina inaudita, Holectypus limitis,* other echinoids; *Gryphea washitaensis.* 38.5 ft.

I. Fort Worth. Thin bedded limestone and marl. *Macraster elegans, aguilerae; Pervinquieria maxima, Exogyra americana. Gryphea washitaensis.* 32 ft.

H. Upper Duck Creek. *Pervinquieria,* echinoids. 34.5 ft.

G. Duck Creek *(Desmoceras* zone). Marly nodular limestone. *Pervinquieria* (abundant), *Desmoceras, Hamites, Macraster, Gryphea tucumcari.* About 13 ft.

F. Post-Kiamichi? clay. *Pervinquieria* (lowest), *Elobiceras* (abundant); *Gryphea tucumcari,* echinoids.

E. Kiamichi. Clay with limy seams. *Oxytropidoceras* (highest, several species), *Engonoceras,* echinoids. At base zone of *Gryphea navia.* E+F= 66.5 ft.

D. Brown limestone, casts of *Trigonia, Protocardia.* 2 ft.

C. Clay (Edwards equivalent). *Oxytropidoceras* (abundant), *Amauropsis, Alectryonia.* 50 ft.

B. Comanche Peak and ?Walnut Limestone. Hard, medium-bedded limestone. *Gryphea marcoui, Exogyra texana,* rudistids, gastropods, echinoids. 91 ft.

A. Basal Sandstone (at outcrop; probably Fredericksburg). *Exogyra weatherfordensis, texana* var. These fossils are more conspicuous in the Fredericksburg division of the Comanchean, but Hill has recorded them from the Trinity division in Travis County. About 50 ft. exposed at outcrop; in wells, 116 to 300 ft.

— Basalmost Comanchean (probably Trinity division). Absent at outcrop, present in a few wells. *Chara* oogonia. Maximum thickness, about 170 ft.

CORRELATION OF ZONE FOSSILS BETWEEN FORT STOCKTON QUADRANGLE AND NORTH-CENTRAL TEXAS

Formation	Bed	Zone No. 25	Zone Fossils	Associated Fossils
Kms?	L	37-40	Main Street Rudists	Compound corals, Actaeonella, Nerinea, Pecten
Kwe	K	29	"Nodosaria" texana Toucasia n. sp.	Alectryonia aff. carinata
Kde	J	23–24	Denton Rudists	Pyrina inaudita, Chondrodonta n. sp.
Kfw	I	19	Pervinquieria maxima	Macraster elegans, aguilerae
Kdc	H	17	Pervinquieria minima	
	G	14	Pervinquieria equidistans	Perv. shumardi, leonensis, kiliani, austinensis, burckhardti, whitei, n. sp. (aff. stoliczkai), sp. aff. trinodosa
	G	12	Desmoceras brazoense	Desmoceras laevicaniculatus and n. sp., Perv. aff. orientalis; Macraster zone; Alectryonia spp.; Kingena.
?	F	11?	"Elobiceras" n. sp. 3	"Elobiceras" serratescens, spp., Hamites comanchensis, fremonti, spp.; Gryphea tucumcari; Pliotoxaster whitei: Alectryonia aff. quadriplicata
Kki	E	10	Gryphea navia	Oxytropidoceras supani, spp.
	D	?	Trigonia	
Kgl	C	10	Oxytropidoceras n. sp.	Oxy. trinitense, acutocarinatum, supani
	B	9	Fredericksburg Rudists	
	A	?		Exogyra weatherfordensis, texana var.

This table indicates the approximate correlation of the Fort Stockton and North-Central Texas sections. With more detailed field work, most of the gaps could be filled in, but it is not necessarily true that all of them could. For example, the rudistid levels have only limited regional extent. This, however, does not affect the general validity of the correlation.

[25]The "zone numbers" refer to Adkins and Winton's *Paleontological Correlation of the Fredericksburg and Washita Formations in North-Central Texas*, Univ. Texas Bull. 1945, pp. 15–31, 1920. Some of the zone fossils of the Fort Stockton quadrangle are described later (p. 55).

is the same northward overlap of the basal beds, as yet insufficiently studied, the same disappearance of the Trinity division by non-deposition (about the latitude of Fort Stockton), and approximately the same lithology and zonation of the higher beds. The zonation of the Trinity and Fredericksburg division has nowhere been as well studied as the Washita zonation, and correlation within those divisions is still attended with some doubts. In addition, there are certain local features in both the northern and the southern sections in Trans-Pecos Texas and northern Chihuahua which differ from anything known in Central Texas. Certain fossils also, are largely or entirely provincial, as *Exogyra quitmanensis* in the Trinity, *Gryphea tucumcari* in the Kiamichi and *Exogyra cartledgei* in the Del Rio.

Basement Sand (A). In the top of this sandstone are found *Exogyra weatherfordensis* Cragin and *Exogyra texana* var., both of which also occur in the base of the overlying limestone. The first named species is a common Fredericksburg marker, and the last named is not a zone fossil.

Fredericksburg Limestone (B). The base contains *Exogyra texana, weatherfordensis, Caprinula,* other *rudists,* other pelecypods and gastropods, *Heteraster, Holectypus* and *Goniopygus.* The top contains various rudists.

Fredericksburg Clay (C). Echinoid zone *(Heteraster, Pliotoxaster, Salenia)* near top. Above this is a zone of large gastropods and of a plicate *Alectryonia.* At the top, under the brown *Trigonia Limestone* is a thin zone of a fine-ribbed *Oxytropidoceras,* the first appearance of this genus. This member contains the highest *Gryphea marcou* Hill and Vaughan.

Kiamichi Trigonia Limestone (D). This prominent, persistent, brownish limestone contains an assemblage of pelecypod casts *(Trigonia, Protocardia);* it is seen at University Mesa and the west end of Twelve Mile Mesa. In the base of the clay (E) just above it is a zone of abundance of *Gryphea navia* Hall. This formation contains the transition from Fredericksburg to Washita: its basal part contains abundant *Oxytropidoceras (supani, acutocarinatum,*

trinitense, n. spp.), and its higher parts contain successively the zones of *"Elobiceras"* (several new species), *"Hamites" (comanchensis, fremonti,* n. spp.) and *Pervinquieria* (earliest species). The *"Elobiceras"* zone (F) contains great numbers of *Gryphea tucumcari* Marcou, a species apparently restricted to the Kiamichi of the northern facies of Trans-Pecos Texas. A prominent zone[26] of limonitic micromorph fossils marks the Kiamichi at Fort Stockton and Kent.

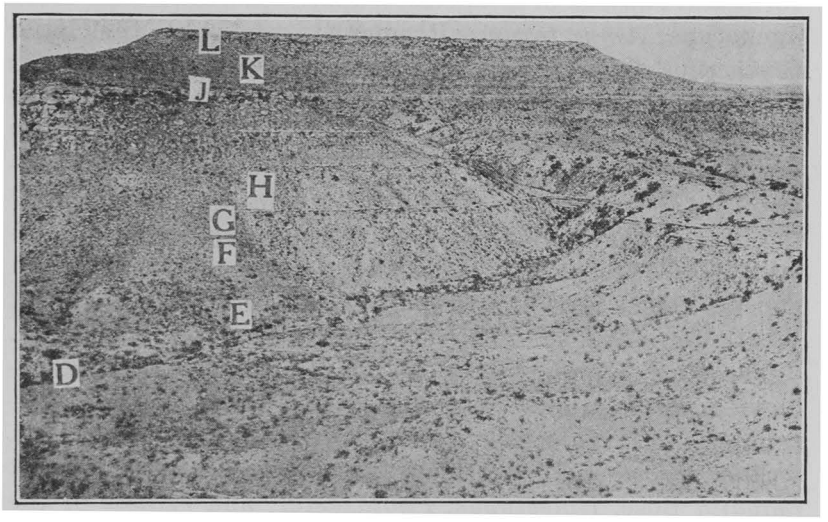

Fig. 7. Cretaceous section at University Mesa. The lettering corresponds to Fig. 6, and to the text.

Duck Creek (G–H). *"Hamites"* and *Pervinquieria* persist into this formation. The basal 13 feet of the Duck Creek is a limestone with a profuse development of *Pervinquieria.* Species referred to *"Desmoceras"* also occur here.

"Schloenbachia" of the Texas literature contains ammonites now referred to several genera. Those species which have numerous, close, non-tuberculate ribs, high keel, and characteristic suture and cross-section *(supani, acutocarinatum, trinitense,* and several new species) are provisionally referred to *Oxytropidoceras* Stieler 1920 although some of

[26]Adkins, Univ. Texas Bull. 2340, p. 79, 1924.

these may later have to be removed from this genus. For the ammonites of the Washita having a rather rectangular cross-section, tuberculate ribs, low keel and characteristic suture the name *Pervinquieria* is used. *(Pervinquieria* J. Boehm 1910=*Inflaticeras* Stieler 1920=*Subschloenbachia* Spath 1921; genotype, *Ammonites inflatus* Sowerby.)[27] *"Mortoniceras" worthense* Adkins is probably a *Neokentroceras.* Some Texas species have been referred to *Prohauericeras* and to *Prohysteroceras.* These ammonites will form the subject of a special paper. *Mortoniceras* Meek (genotype: *Amm. texanus* Roemer) is confined to the Upper Cretaceous (Austin Chalk). Several Duck Creek species have been referred to *Desmoceras* Zittel. These cannot be discussed here, but some of them probably belong to new genera. The species of *"Hamites"* likewise require revision. There are two prominent *Macraster* zones, one at the base of the Duck Creek, as is demonstrated by the isolated Hill 3175 at Five Mile Well between Fort Stockton and the Odom Ranch, and the other at the top of the Fort Worth limestone, as in University Mesa or Seven Mile Mesa.

The *Fort Worth Limestone* (I) is marked by *Pervinquieria maxima* (Lasswitz 1904) and near its top, by a zone of the large echinoid *Macraster (aguilerae, elegans).*

The *Denton* (J) is marked by an abundance of *Pyrina inaudita* Böse, *Holectypus, Pliotoxaster,* and *rudists* of the Middle Cap Rock.

The *Weno* (K) lying between the Mid and Upper Cap Rocks, contains scattered rudists *(Toucasia* n. sp.) and a zone of *"Nodosaria" texana* Conrad. The Pawpaw was not located at Fort Stockton; in North-Central Texas it is characterized by *Neokentroceras worthense* (Adkins) and the earliest of the true *Stoliczkaia* (S. *adkinsi* Böse). The *Main Street* (L) at Fort Stockton is rudistid limestones with corals and gastropods. Its typical zone fossils were not found here, but in the similar section at Kent there are banks of *Exogyra arietina;* in Central Texas this level is

[27]L. F. Spath: On the zones of the Cenomanian and the uppermost Albian. Proc. Geol. Assoc., XXXVII, 420–432, 1926. Dr. Spath kindly called my attention to Boehm's reference.

marked by the highest occurrence of *Pervinquieria* and by *Turrilites brazoensis* Roemer.

There are thus six principal ammonite genera which serve as zone fossils in the Cretaceous at Fort Stockton:

(1) *Oxytropidoceras* (Plate 3, figs. 1–3).

Inflated or flat-flanked whorls; tall keel; flexuous, fine, crowded ribs; no tubercles; characteristic suture.

Horizon: Fredericksburg (mainly Kiamichi).

Species: The following are found at Fort Stockton: *O. acutocarinatum, supani, trinitense, kiowanum* (Twenhofel), *chihuahuense, bravoense, belknapi* and some new species.

(2) *Pervinquiera* (Plate 3, fig. 4; plate 5).

Generally rather rectangular cross-section; low rounded keel; straight or flexuous ribs with1-3 rows of tubercles.

This genus is very abundant, especially in the Duck Creek limestone. In Texas the genus can be divided into five groups, and about 25 species are known. Most of these occur near Fort Stockton.

Horizon: Washita, and Upper Kiamichi.

(3) *"Elobiceras"* (Plate 4, fig. 3).

Tall cross-section; rather straight ribs with usually numerous spiral whorls of imbrications or nodes; characteristic suture.

Horizon: Kiamichi. *(E. serratescens* Cragin 1893, and several new species.)

(4) *"Desmoceras"* (Plate 6, figs. 1–2).

Keelless, venter rounded; cross-section of volution variable, mostly thick, some taller; characteristic sutures; mostly large ammonites.

Species: Several *(D. brazoense, laevicaniculatum,* n. spp.), probably of several genera. Some of the species have generic characters which combine those of *Uhligella* and *Puzosia.*

Horizon: Base of Duck Creek limestone.

(5) "Hamites" (Plate 4, fig. 2).

Uncoiled ammonites; straight or curved limb fragments generally found.

Species: *H. fremonti, comanchensis,* spp. Probably several genera are represented.

Horizon: Duck Creek limestone.

(6) *Engonoceras* and allied genera (Plate 2, figs. 3–5).

Venter acute, at least in some stages, convex, square or excavated in adult; ribs and tubercles reduced; suture of numerous simplified elements. Several species.

Horizon: More frequent in Fredericksburg.

Until further standard sections are established in both facies in Trans-Pecos Texas, a good universal zonation cannot be given. The features of the Fort Stockton section are typical for most of the northern facies in Trans-Pecos Texas. It is practically the same as the Kent section. The Washita section at Black Mountain and other places north of Sierra Blanca is similar, but the Fredericksburg is composed of ferruginous sandstone with abundant molluscan casts (*Alectryonia* aff. *carinata, Protocardia, Trigonia* and others), and the *Desmoceras* zone of the Duck Creek rests directly on this sandstone. At Black Mountain and at Kent the basal sand rests directly on Permian limestone. The Van Horn-Sierra Blanca-Quitman sections, described by Richardson and Baker and characterized among other things by thick Trinity, form a special study. Several thick Washita sections of the northern facies are described from southern Hudspeth and Culberson counties by Baker.[28] The El Paso section is shalier and sandier than at Fort Stockton, has two principal limestones and special features in the Main Street and Buda. Böse[29] has described from northern Coahuila valuable, but essentially local, sections, which later will contribute many data to the establishment of a general section.

The classic and much debated localities near Tucumcari, eastern New Mexico contain an association of *Gryphea tucumcari* Marcou, *Alectryonia subovata* Shumard (*"marshi"*), and *Alectryonia quadriplicata* Shumard, an association which, as the preceding discussion shows, indicates the Kiamichi,[30] or at the highest, the basal Duck Creek formation. Baker records at Tucumcari Mountain beneath the "Dakota" 325 feet of gray buff sandstones with soft cream-colored sands below, containing at the top *Turritella* and

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[28]Charles Laurence Baker: Exploratory geological reconnaissance in southwestern Trans-Pecos Texas. (Ms.)

[29]Emil Böse, Ms. on Cretaceous and Tertiary of southern Texas and northeastern Mexico.

[30]*Alectryonia quadriplicata* has already been recorded from the Kiamichi of Bosque County. (Adkins, Univ. Texas Bull. 2340, p. 41.)

Cardium, and at a level of 50 feet below the top an abundance of *Gryphea tucumcari.*[31].

Eastward from Fort Stockton the Fredericksburg thickens and indurates, and the shale is replaced by limestone. At a butte near the Fort Stockton-Sheffield road 33 miles from Fort Stockton the section shows the typical northern shaly facies, in both the Fredericksburg and Washita divisions. Near the Perry wells there is a marked transition to the more limy southern section. At Sheffield the section, particularly the portion between the Middle and Upper Cap Rocks, is noticeably indurated, but some of the ammonite zones persist. Writers disagree on the correlation of the section near Sheffield. This disagreement is mainly caused by misunderstanding of the fossil zonation. Liddle and Prettyman traced their "third division of the Edwards" as far west as the cap rock of Seven Mile Mesa,[32] i.e., the Middle Cap Rock. Their third division thus includes the top part at least of the Washita section above summarized. Various geologists have traced their second and third divisions over eastern Pecos County, where the cap rocks and bedding planes seem to persist for considerable distances. The fossils listed from their Camp Section, three and one-half miles east of Sheffield in the lower part of the second division of the Edwards indicate that this level is Kiamichi[33] Typical Duck Creek fossils have been found near Sheffield at a slightly higher level. Some of the second division and all of the third division, totalling somewhat less than 285 feet at this place, are therefore Washita. About a mile east of Sheffield typical Duck Creek ammonites *(Pervinquieria* aff. *trinodosa, shumardi,* n. spp.) occur just above a prominent ledge about 250 feet above the base of the cliff, and the strata above this ledge are undoubtedly of Washita age.

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[31]Charles Laurence Baker, Contributions to the stratigraphy of eastern New Mexico. Am. Jour. Sci., 49, 99–126, 1920, p. 120; W. F. Cummins, Geol. Surv. Texas, 3d Ann. Rept., 1892, pp. 201–210 (list of fossils).

[32]Liddle and Prettyman: Univ. Texas Bull. 1857, p. 66.

[33]Liddle and Prettyman: *Ibid.*, pp. 22–23, 55.

A level of *Oxytropidoceras* occurs immediately under these fossils. About 150 feet above the Duck Creek ammonite zone is a prominent, medium-bedded cap rock, which is conspicuous over the whole Sheffield region and is Upper Washita in age. Two miles north of Pandale about 200 feet above the valley floor (Howard's Draw) is a prominent ledge which is directly overlain by medium-bedded limestone with Duck Creek ammonites. From here to the mouth of Devil's River many of the bedding planes disappear and the limestone assumes the massive bedding typical of the lower Pecos valley. The precise zonation of the "Devil's River" limestone has not yet been worked out, but Georgetown fossils are known to occur in it.

The Washita division indurates toward the east and the south, and probably thins in the same direction. In the rim of the Sierra Madera and at Round Mountain, the section is more indurated than at Fort Stockton. Near Gaptank there is an indurated Washita section extending to the Upper Cap Rock, and containing, among other zones, the Duck Creek ammonite zone. The sections at Gaptank, Altuda and in the eastern and southern rims of the Marathon Basin demonstrate the northward overlap of the Trinity and the transitional features between the northern and southern facies, but cannot be detailed here. Lithologically the sections at Gaptank and at Sheffield are rather similar.

In Upton County the Cretaceous section is somewhat as at Fort Stockton. Hoots and others have published sections which indicate a variable amount of basement sand (given as 150–300 feet) thin Fredericksburg, mainly limestone (given as low at 40 feet) and a thin limestone section of Washita. Various correlations given for this area are in hopeless conflict. Sellards and Patton[34] record in the Big Lake oil field 100–200 feet of Basal Cretaceous sands, overlain by 200–400 feet of Comanchean limestones. Liddle and

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[34]E. H. Sellards and Leroy T. Patton: The subsurface geology of the Big Lake oil field, Bull. Am. Assoc. Petr. Geol., 10, No. 4, 365–381, 1926.

Prettyman record numerous sections along the Pecos River from about Girvin to below Chandler.[35]

Liddle and Prettyman[36] have questioned the reliability of zone fossils in this region. They cite from Seven Mile Mesa certain fossils which they claim were considered characteristic of the Georgetown but which "have been found throughout the Edwards also," and therefore have a greater vertical range than was anticipated. These are *Lima waco-ensis, Pholadomya texana, Gryphea pitcheri* Morton, *Vola wrighti* and *Kingena wacoensis.* These are not zone fossils, with the possible exception of the last two. An inspection of the zonation on page 51 should make it clear that Seven Mile Mesa contains typical Washita strata. Shumard's fossil lists from localities along the Pecos River agree with this interpretation as do the lists given by Liddle and Prettyman

Correlation by rudistids will be impracticable in this area until the ranges of the various species are known. Rudistids appear in the Fort Stockton region in at least three different levels, separated by non-rudistid strata which can be correlated by their ammonites and other fossils. The mere occurrence of rudistids, therefore, marks a facies not a formation. In Central Texas this facies appears in the Glen Rose, the Edwards, and the Austin-Taylor. Near Fort Stockton it appears in the Edwards, the Denton, and the Main Street. At places in northern Mexico it occupies considerable parts of the Comanchean column. The distribution of the rudistid facies in the Rio Grande region has not yet been traced, but judging from other areas this facies may be found to interfinger between non-rudistid beds, so that in a region like Fort Stockton the rudistid layers may be the northern expression of this interfingering. Taff[37] first called attention to a high rudistid layer in Trans-Pecos Texas. The confusion between these upper levels and the Edwards arises in part from our ignorance as to the exact

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[35]Liddle and Prettyman: *Ibid.*, pp. 52–60.

[36]Liddle and Prettyman: *Ibid.*, p. 65.

[37]J. A. Taff: Geol. Surv. Texas, 2d Ann. Rept., pp. 720–721, 1891.

fossil contents of the upper rudistid zones. In the Mediterranean region the rudistid partition has proved to be generally distinct and reliable, but such rudistid zones have not yet been established in Texas. In addition, the Edwards formation suffers through vagueness in the specification of its type locality. It was formerly called Barton Creek limestone, from the locality near Austin, and this name was in 1901 changed to Edwards. The Edwards Plateau, even in Edwards County, has various beds at its surface, some of them High Washita (Del Rio, at least). Furthermore, Hill states[38] that the top of the Fredericksburg Division was originally located on the basis of ammonite ranges (i.e., essentially at the top of *Oxytropidoceras),* but was later changed to a rudistid basis to conform to the well known rudistid level at Austin. When then rudistids were found at higher levels, the top of the Edwards was left undefined paleontologically. Hill[39] later postulated that the Middle Cap Rock in the vicinity of Fort Stockton is laterally continuous with the Edwards limestone at Austin, the lithologic and paleontologic facies having moved up, or transgressed through geologic time, until it occupied a position above the Georgetown and Duck Creek formations near Fort Stockton.

LOCAL SECTIONS

SECTION OF SEVEN MILE MESA, EAST END (1027)

	Feet
Middle Cap Rock: Limestone, superficially indurated whitish interiorly, weathering gray, mainly crystalline; supports a growth of (1) lechuguilla, (2) Opuntia spp., (3) ocotillo, (4) pitahaya, (5) soapweed, (6) catsclaw, (7) tasajillo, (8) blackbrush, (9) greasewood, (10) red Mammilaria, (11) grasses, (12) Selaginella, roughly in order of abundance	10+
Rudistid and nodular limestone; near base, at line of prominent receding layer is zone of abundance of *Pyrina inaudita*	28

[38]R. T. Hill: U. S. Geol. Surv., 21st Ann. Rept., pt. 7, pp. 118–119, 1901.

[39]R. T. Hill: Two limestone formations of the Cretaceous of Texas which transgress time diagonally. Sci., (n.s.), LIII, No. 1365, 190–191, Feb. 25, 1921.

	Feet
Nodular whitish limestone, medium-bedded; *Nautilus texanus, Macraster* cf. *elegans*	72
Ferruginous limestone, weathers to a bench	1
Whitish chalky limestone	10.5
Calcareous clay	13.5
Whitish chalky limestone, top a thin hard ledge	10.5
Limestone, whitish and chalky; ferruginous stain; forms bench	2
Soft whitish limestone, chalky and nodular. *Gryphea tucumcari, corrugata, Pervinquieria* aff. *trinodosa* (tall), *kiliani,* n. spp.; *Desmoceras* (several species) in base; top of *Desmoceras* zone	13
Calcareous shale, weathering brownish; near base, a few scattered ledges of yellowish limestone; *Desmoceras* sp.	45.5
Three 4-inch limestone seams and two intervening layers of calcareous clay, all iron-stained; *Exogyra texana*	5.2
Brownish calcareous clay; *Exogyra texana, Gryphea marcoui*	10.2

Interval, Top Desmoceras to top Middle Cap Rock, 147.5 feet.
Desmoceras to Pyrina, 107.5 feet.

This section exposes the formations Kiamichi to Denton, inclusive.

SECTION OF SEVEN MILE MESA, WEST END (1028)

	Feet
Mid Cap Rock, harder rudistid limestone; *Eoradiolites,* n. sp. *Chondrodonta* n. sp., compound corals, gastropods	15
Limestone, soft, shelly, receding. *Pyrina inaudita, Holectypus limitis, Heteraster, Pliotoxaster, Gryphea washitaensis*	5
Limestone, compact, in part rudistid-bearing	10
Limestone, nodular, soft, fossiliferous; base a receding layer	21.5
Calcareous clay with limestone seams; fossils	86.7
Projecting gray limestone ledge	11
Limestone, whitish, nodular; *Desmoceras* zone	13
Calcareous clay with scattered limestone seams; *Gryphea corrugata, Exogyra texana, Engonoceras, Heteraster;* at base a zone of *G. navia*	64
Calcareous iron-stained shale; near top is brown limestone layer; 20 feet above base is a bluish-black gypsiferous shale with thin platy seams of red sandstone	56.1
Brown ferruginous limestone and calcareous shale	6.5
Brown limestone	0.5
Clay; *Oxytropidoceras acutocarinatum, trinitense; Cyprimeria* zone	10
Gryphea limestone and shelly clays	20
Gray limestone, and some clay, about	40
Hard rudistid limestone	20+

About one mile west of the point of the mesa is a small exposure of basal Cretaceous sandstone. The top 162 feet of this section is Washita, from the top of the Denton to the base of the Duck Creek limestone. Below this the Fredericksburg shale and most of the limestone are exposed. The Kiamichi contains a faunule, poor in number of species but rich in individuals, of limonite micromorphs, mainly ammonites. A similar faunule occurs in the same horizon at Kent.

SECTION AT GAP IN NORTH SIDE OF UNIVERSITY MESA
(Section 33, Block 24, University Lands; 1026)

	Feet
Upper Cap Rock (probably Mainstreet limestone). White, nearly pure, coarsely crystalline limestone, locally gritty, weathers grayish; etched potholes and schratten weathering. Fossils: *Actaeonella, Nerinea, Pecten* (species as in reef facies of Central Texas and Portugal); radiolites, caprinids, sponges, compound corals	25
Thin to medium-bedded gray limestone interbedded with calcareous clay. Near top a zone of nodular flints and *"Nodosaria" texana* Conrad. Near middle a zone of *Toucasia* n. sp. Fossils: *Alectryonia* aff. *carinata, Pervinquieria* cf. *wintoni,* gastropods, pelecypods. Probably Weno	81
Middle Cap Rock: white rudistid limestone, weathering gray; exhibits schratten weathering and etched potholes. Fossils: sponges, compound corals, *Nerinea, Pecten.* Prominent zone of *Pyrina inaudita* and other echinoids. Base is a massive, nodular limestone with a prominent zone of *Macraster aguilerae,* cf. *elegans* and *Gryphea washitaensis* (Fort Worth limestone) grading into next member	38.5
Medium-bedded, alternating marly limestones and calcareous clay; *Pervinquieria* sp., *Exogyra americana, Gryphea washitaensis; Pecten subalpinus.* Equivalent of the Fort Worth limestone	32
Medium and thin-bedded alternate layers of soft, chalky limestone and calcareous clay. *Pervinquieria* (several species, rare), *Alectryonia* cf. *Marcoui,* cf. *carinata, Gryphea wash itaensis, corrugata, Pecten, Lima.* This member is probably Duck Creek limestone	34.5
Nodular, marly, thin-bedded limestone with some calcareous clay. "Trinodosa-Desmoceras Zone," lower Duck Creek limestone; this is the base of Washita division. Fossils: *Pervinquiera aguilerae, austinensis, burckhardti, kiliani,*	

Feet

leonensis Conrad, *minima, nodosa, shumardi,* aff. *ootaturensis,* aff. *orientalis,* aff. *stoliczkai,* aff. *trinodosa,* n. spp. cr, p. st); *Desmoceras brazoense* and n. spp.; *Hamites fremonti, comanchensis* and n. spp.; *Nautilus* cf. *texanus; Gryphea corrugata, tucumcari, washitaensis, Alectryonia* cf. *marcoui, Pecten, Lima, Pinna, Protocardia* 13

Calcareous clay with thin limestone seams; basally is a shell marl. Upper portion: *Elobiceras serratescens* and n. spp. (aff. *angustum, arietiforme, flexuicostatum* and others), *Hamites comanchensis* and n. spp.; *Gryphea tucumcari* (abundant), *corrugata, Alectryonia* cf. *marcoui, subovata,* sp., *Pecten subalpinus, Lima wacoensis; Heteraster, Pliotoxaster.* The exact age of this portion was not determined; it may be post-Kiamichi.

Lower portion: mainly a shell marl, a calcareous clay with abundant *Gryphea corrugata,* and at the base, a zone of *Gryphea navia.* Highest *Oxytropidoceras (acutocarinatum, supani, trinitense,* n. spp.), and *Exogyra texana;* pyrite micromorphs; age, Kiamichi 66.5

Brown, shelly limestone. *Protocardia, Trigonia, Cyprimeria;* about 2

Brownish, calcareous clay. Fossils: *Oxytropidoceras acutocarinatum, supani, trinitense, bravoense; Alectryonia* cf. *subovata, Gryphea marcoui, Exogyra texana,* gastropods; *Pliotoxaster, Heteraster, Holectypus, Salenia; about* 50

Beneath this is an irregularly exposed limestone, which extends to a point about a mile north of University Mesa; the hard layers form dipping cuestas and the soft layers intervening depressions. The section continues down into the basal Cretaceous sandstones; elevation of nearby monument, 2783 feet. At the west end of Twelve Mile Mesa this Fredericksburg limestone is about 91.5 feet thick.

(Continuation on Section 6, Block 26, University Land; elevation top sandstone, 2759 feet.)

Feet

Limestone, gray 3

Limy clay; *Heteraster, Pliotoxaster, Goniopygus, Tylostoma* 3

Limestone, gray soft 5

Limestone, gray, hard; top 4 feet massive, forms shelf, exhibits schratten weathering, supports growth of ocotillo; basal 5 feet, nodular, softer, with *Lunatia pedernalis* 9

Limestone, softer, nodular; *Exogyra weatherfordensis, texana* 4

Basal Sandstone (concordant contact):

Sandstone, grayish to brown, calcareous, nodular; *Exogyra texana* 2

	Feet
Sandstone, indurated, ferruginous, dark brown, forms horse-shoe ledges in streams; *Exogyra weatherfordensis, texana* var.	0.8
Sandstone, argillaceous, soft, yellowish to grayish	2
Sandstone, ferruginous, weathers dark reddish-brown, very honeycombed	2
Sandstone, soft, light yellow, weathers gray and vari-colored (purplish, lavender)	4
Sandstone, ferruginous, dark red-brown, with fucoid-shaped concretions	1
Sandstone, weathers gray, thin-bedded, some cross bedding, many small nodules	10
Sandstone, yellowish, weathering gray, thin-bedded, some cross bedding, no nodules	7
Sandstone, dark brown, ferruginous, no nodules, weathers to long slabs	6
Sandstone, beds of 3 feet thickness, ferruginous, dark red-brown, weathers to blocks 2 to 4 feet across, interiorly a network of white and brown areas; no cross bedding, no fossils; growth of large Echinocactus	14
Sandstone, medium-bedded, dull red-brown, consisting of small nodules (2 to 3 mm.), weathers to continuous ledge	5

The west end of Twelve Mile Mesa shows an identical section of two dark red-brown ferruginous sandstone layers separated by a softer gray-purplish sandstone. The sandstones above detailed are dipping towards the University Mesa, and it is probable that in the salt flat north of this locality the underlying red beds reach the surface beneath the alluvial cover; no shallow well data are at hand to check this supposition.

SECTION AT WEST END OF TWELVE MILE MESA (1032)

	Feet
Limestone above the Upper Cap Rock; estimated remaining thickness	25
Upper Cap Rock; crystalline, partly rudistid limestone	38
Nodular, thick-bedded limestone above; below, alternate layers of chalky argillaceous limestone and calcareous clay; the section is more indurated than in University Mesa	160
Desmoceras-"Trinodosa" Zone. ,Nodular clayey limestone with numerous ammonites, *Desmoceras* spp. and *Pervinquieria* spp. This layer is roughly 12 feet thick; below it is a calcareous, iron-stained clay with scattered thin limestone	

	Feet
seams. Fossils: *Hamites fremonti, comanchensis, Desmoceras* 2 spp., *Pervinquieria kiliani,* aff. *trinodosa, Elobiceras, Gryphea corrugata, tucumcari, washitaensis, Alectryonia,* aff. *subovata, Pecten subalpinus, Lima, Protocardia, Trigonia, Kingena; limonitic* micromorphs	72.7
Brown limestone, persistent layer, about	3
Iron-stained clay; *Exogyra texana, Gryphea marcoui,* echinoids; about	50
Hard gray Fredericksburg limestone; *Tylostoma,* gastropods, some rudistids; at the base is a softer argillaceous limestone with *Exogyra weatherfordensis* and *Exogyra texana* var. (as at University Mesa)	91.5
Basal Sandstone:	
Sandstone, two brown ferruginous layers separated by a purplish layer; general medium-bedded, some cross bedding, some nodules; the top contains a layer of *Exogyra texana* (flared edge) and *E. weatherfordensis;* thickness exposed, about	50

A monument at the top of this section has an elevation of 3713 feet. The thickness from the top of the brown limestone to the top of the Upper Cap Rock is, at University Mesa 291.2 feet, at Twelve Mile Mesa 270.7 feet, thus indicating a southward thinning of the Washita section. The above locality exhibits the rocks from the upper part of the basal Cretaceous sand (probably Fredericksburg at this place) up to the Upper Cap Rock (high Washita, probably Mainstreet limestone). The section is given by Baker and Bowman, who cite the following fossils from above the brown limestone ledge: *Kingena wacoensis, Diplopodia* cf. *texanum, Pyrina parryi.* Large rudistids, with fragments up to ten inches long are reported from the limestone ridge crossing the road about 3 miles south of Belding station, and near the southwest corner of the Fort Stockton sheet.

Some small scale faulting is reported from the east end of Twelve Mile Mesa. The log of the Belding well (Arnett, Crawford and Williams) is given in University Texas Bulletin 1752, p. 116; in the Bureau of Economic Geology is a sample from 315 feet, which is described as being probably basal Comanchean.

SECTION ON NORTH SIDE OF FIVE MILE MESA (1042)

	Feet
Upper Cap Rock, rudistid limestone; caprinids; exposed about	15
Limestone, more massive near top, alternating with marl layers near base. About 15 feet below bottom of Upper Cap Rock is a zone of *"Nodosaria" texana* Conrad, in nodular limestone; no chert layer was seen here. Between the upper and the middle cap rocks is a zone of *Toucasia* n. sp	77
Middle Cap Rock; reef limestone with caprinids	15
Marly and nodular limestone and calcareous clay; Fort Worth and Duck Creek fossils; exposed	76.8

The *Desmoceras* horizon is here concealed by alluvium, but the higher Duck Creek limestone with *Pervinquieria* is exposed. This mesa is a "double-deck" mesa, in which the two parts are formed by the two cap rocks. A prominent outlier of the upper cap rock and the underlying Weno stands as a butte on top the Middle Cap Rock. At the east point of the mesa, the basal Duck Creek is seen, and beneath it, the Kiamichi clay with an abundance of *Gryphea corrugata, Alectryonia* cf. *quadriplicata, Macraster* cf. *elegans* (float) and other fossils. At the northwest corner of the mesa, south of the Price Ranch house, is an exposure of Duck Creek and Kiamichi with abundant characteristic fossils.

FOSSILS FROM NEEDLE PEAK (SECTION 4, BLOCK 114, G. C. S. F. RY.)

This peak has Kiamichi clay near the base, Duck Creek formation on the slopes and Fort Worth limestone at the top. Böse has identified the following fossils from this locality (Univ. Texas Bull. 1753, p. 115).

Schloenbachia cf. *nodosa (Pervinquieria)*
Epiaster elegans (Macraster)
Alectryonia marcoui.
Gryphea pitcheri
Vola sp.
?Tapes

SECTION AT LEON SPRINGS (1031)

	Feet
Middle Cap Rock	5+
Medium and thin-bedded limestone and calcareous clay; about	60

	Feet
Iron-stained limestone and calcareous clay; *Pervinquieria, Macraster* sp., Duck Creek fossils	5
Limestone, weathering whitish; *Pervinquieria,* small *Marcaster*	10
Limestone, soft, weathering whitish, not nodular; *Pervinquieria austinensis, kiliani, leonensis, equidistans?,* aff. *trinodosa, shumardi*	8
Fossiliferous limestone consisting of large chalky nodules and marly cement; top an oyster bed, forming shelf. *Desmoceras* Zone. Fossils: *Desmoceras brazoense* and spp., *Hamites comanchensis, Pervinquieria* spp.; *Alectryonia* aff. *carinata,* cf. *marcoui, subovata?, Gryphea corrugata, tucumcari, Kingena, Pliotoxaster, Heteraster* and many other Duck Creek fossils	3.5
Calcareous shale (best exposed at east end); about	25

The dip is northerly, towards the Balmorhea-Stockton road.

Major William H. Emory of the Mexican Boundary Survey visited this locality in 1853 or 1854 and collected fossils which were described by Conrad in the report of that survey in 1857 (Mex. Bdry. Surv., II, 142). Conrad's list on page 142 disagrees with his localities as given in his descriptions. According to his description, Leon Springs should be the type locality of the following fossils:

Ammonites geniculatus Conrad
Ammonites leonensis Conrad[40]
Lima leonensis Conrad
Trigonia texana Conrad
Turritella leonensis Conrad
Protocardia filosa Conrad
Cardita eminula Conrad
Cytherea leonensis Conrad
Pyrina parryi Hall
Terebratula leonensis Conrad
Capsa texana Conrad

Conrad (Mex. Bdry. Surv., p. 142) lists the following fossils from Leon Springs in addition to those above given:

Ammonites flaccidicosta Roemer
Ammonites texanus var. Roemer
Hamites larvatus Conrad
Exogyra arietina Roemer
Exogyra laeviuscula Roemer
Exogyra matheroniana d'Orbigny
Gryphea pitcheri Morton
Neithea texana Roemer

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[40]Locality of *Ammonites leonensis* is not stated in the Boundary Report, but the holotype in the United States National Museum bears the label "Leon Springs." It should be noted that the horizon of *P. leonensis* (Conrad) is Duck Creek, not Fort Worth limestone.

Neithea occidentalis Conrad
Protocardia multistriata Shumard
Pholadomya sanctisabae Roemer
Cyprimeria texana Roemer
Caprina crassifibra Roemer
Natica sp.
Holectypus planatus Roemer
Toxaster texanus Roemer
Cyphosoma texanum Roemer
Terebratula choctawensis Shumard
Turbinolia texana Conrad

The first five fossils named are probably not from this locality; however *Hamites larvatus* may be the same as *Hamites comanchensis. Exogyra "matheroniana"* is near *texana* Roemer; the *Gryphea pitcheri* is *G. tucumcari.* Leon Springs is the type locality of *Heteraster adkinsi* Lambert,[41] a species based on material identified by Clark as *Enallaster texanus* Roemer.

FOSSILS FROM COMANCHE SPRINGS (ELEVATION 2916–2930)

Near the main spring of the group, there is exposed about 10 feet of lower Kiamichi or Upper Fredericksburg clay. Some exposures were made in opening the springs just back of the Mexican church (the Duck Creek fossils here were brought in from the mesas). On the Sanderson road, just out of Fort Stockton are Kiamichi exposures, overlain by recent caliche-conglomerate, as above Comanche Springs.

Oxytropidoceras trinitense (Gabb)
Oxytropidoceras supani (Lasswitz)
Oxytropidoceras acutocarinatum (Shumard)
Engonoceras sp. indet.
Pecten irregularis Böse
Pecten subalpinus Böse
Plicatula incongrua Conrad
Ostrea sp.
Gryphea sp.
Exogyra texana Roemer
Pholadomya sanctisabae Roemer
Cyprimeria sp.
Lima wacoensis Roemer
Trigonia sp.
Homomya sp.
Tapes sp.
Isocardia sp.
Turritella sp.
Cerithium sp.
Heteraster sp.

[41]J. Lambert, Considérations sur les échinides de la Commanche série du Texas. Bull. Soc. Géol. France, XXVI, fasc. 3–4–5, pp. 263–278, 2 textf., 1926 (1927).

Baker and Bowman[42] list from this locality:

Engonoceras sp.
Exogyra texana Roemer
Exogyra n. sp.
Exogyra sp.
Vola subalpina
Vola irregularis
Lima wacoensis Roemer
Lima sp.
Trigonia sp.
Pholadomya sp.
Enallaster texanus?

SECTION AT FIVE MILE WELL (ELEVATION 3175 FEET)
(Dip, 2°–3° N15W)

	Feet
Duck Creek:	
Limestone, white, nodular, soft; *Desmoceras, Pervinquieria* aff. *trinodosa, Hamites.* (Desmoceras Zone)	14.5+
Kiamichi:	
Clay, calcareous, weathers light yellowish-brown; *Kingena, Gryphea tucumcari*	10
Limestone, brownish-yellow, nodular	0.5
Clay, yellowish, calcareous	2.5
Limestone, brownish-yellow, argillaceous; *Protocardia filosa*	0.4
Clay, yellowish, calcareous ;*Pliotoxaster, Heteraster, Macraster* (worn), *Kingena*	1.7

This locality demonstrates that the Duck Creek Macrasters are in situ, since the location of this isolated remnant precludes any contamination of the outcrop from a higher horizon. The Fort Worth *Macraster* zone may be seen to advantage at the gap in University Mesa, and generally, just beneath the Middle Cap Rock. Other fossils from Five Mile Well remnant are:

Desmoceras 2 species
Pervinquieria equidistans
Pervinquiera aff. *trinodosa*
Pervinquieria kiliani
Alectryonia (zigzag sp.)
Cyprimeria sp.
Lima sp.
Trigonia sp.
Hamites fremonti
Gryphea corrugata
Gryphea tucumcari
Pecten subalpinus
Pliotoxaster spp.
Heteraster sp.
Macraster, 2 species
Kingena wacoensis

[42]Baker and Bowman: Univ. Texas Bull. 1753, p. 115.

SECTION AT HILL 2903, NEAR GRANDFALLS ROAD, 6 MILES NORTH OF FORT STOCKTON

This 35-foot exposure includes the top part of the Kiamichi and the base of the Duck Creek limestone. Among the fossils are: *Pervinquieria shumardi,* aff. *leonensis, Macraster* sp., *Pliotoxaster* sp., *Gryphea corrugata, Alectryonia* (plicate species).

There is a 40-foot exposure of Upper Kiamichi clay and basal Duck Creek limestone. Among the fossils found are:

Hamites comanchensis A. & W.
Gryphea corrugata Hill & Vaughan
Alectryonia sp. (plicate)
Cyprimeria sp.
Pholadomya sp.
Isocardia sp.
Protocardia sp.
Macraster sp.
Heteraster sp.
"Diplopodia" sp.

SECTION AT BUTTE, NORTH SIDE OF FORT STOCKTON-SHEFFIELD ROAD, ABOUT 33 MILES EAST OF FORT STOCKTON (1033)

This is a yellow butte, lacking the middle cap rock, in University Block 18?, 26.6 miles east of junction of Girvin and Sheffield roads, and 12.3 miles east of Tunas Spring.

	Feet
Limestone, whitish, rather soft and nodular; caps hill	12.0
Limestone, grayish, chalky, with iron nodules; forms prominent bench. This bench, lying next below the Middle Cap Rock, is seen in the isolated butte about 1.5 miles northeast of this hill	1.8
Limestone, soft, shaly	34.5
Limestone, soft, yellowish; forms inconspicuous bench; top Duck Creek	21.5
Clay and soft yellow limestone seams; *Desmoceras* zone	14.3
Limestone, soft, chalky, whitish; *Gervilliopsis, Desmoceras*	3.3
Clay, calcareous, weathers light yellowish; *Alectryonia*	10.5
Limestone, soft, yellowish; *Hamites comanchensis, Pervinquieria*	0.5
Clay, calcareous	1.0
Limestone, soft, yellow	0.5
Clay, calcareous	1.0
Limestone, soft, yellow	0.6
Shell marl; top of *Gryphea* zone; *Gryphea corrugata* (abundant), *Alectryonia, Pervinquieria*	2.5
Very shelly limestone, soft, yellowish; the shells are purplish; *Gryphea* spp., *Elobiceras* (close ribs)	0.4
Shelly clay; *Cyprimeria* zone	1.0

	Feet
Limestone, shelly	0.5
Shell marl	2.0
Shelly limestone	0.8
Shell marl with limestone seams	5+

The twelve layers at bottom of the section contain *Hamites* and *Elobiceras* but no *Oxytropidoceras,* and this locality, like others in the Fort Stockton region, shows that *Pervinquieria* and *Oxytropidoceras* do not overlap. Fossils from this locality are:

Desmoceras, 2 species
Pervinquieria aff. *trinodosa*
Pervinquieria kiliani
Pervinquieria leonensis
Hamites comanchensis
Elobiceras, several species
Gryphea navia
Gryphea corrugata
Gryphea tucumcari
Alectryonia sp.
Inoceramus sp.
Macraster sp.

SECTION AT TRIPLE PEAK (SECTION 160,? BLOCK 3, T.P. RY.)

This is a triple hill, about 2 miles west of the Stockton-Alpine road, and about 16 miles southwest of Fort Stockton. The section includes from the Fredericksburg limestone up to at least the Middle Cap Rock; it totals about 200 feet in thickness.

I. Dense white limestone capping hills.
H. Shale and soft limestone.
G. White limestone, rather soft and nodular; *Desmoceras* zone. Many ammonites, especially *Pervinquieria* aff. *trinodosa, nodosa, kiliani,* aff. *leonensis, Desmoceras brazoense,* spp.
F. Calcareous clay; *Gryphea corrugata, tucumcari.*
E. Calcareous clay; *Gryphea navia.*
D. Brown limestone; *Trigonia* and other pelecypod casts.
C. Calcareous clay. Echinoids abundant and well preserved *(Heteraster* aff. *texanus, Pliotoxaster, Holectypus, Salenia); Oxytropidoceras supani, trinitense, Engonoceras, Homomya* cf. *alta, Exogyra texana,* Caprinids; gastropods abundant.
B. Hard white limestone (Fredericksburg)
A. The basal Cretaceous sandstone outcrops a short distance south and southwest of these peaks.

SECTION IN ROUND MOUNTAIN (NORTHEAST QUARTER OF THE SIERRA MADERA QUADRANGLE)

Elevation of cairn on top of butte is 3606 feet. The section extends from Kiamichi clay to the Middle Cap Rock.

Higher parts of the section outcrop on the long scarp east of this outlier.

		Feet
J.	Middle Cap Rock. Compact limestone, some of it rudistid-bearing	50
	This limestone is mainly white, nodular, hard, with schratten weathering; caprinids and gastropods.	
H-I.	Mainly compact limestone, some calcareous clay; about	120
G.	White limestone; top contains prevailingly *Pervinquieria* aff. *trinodosa, shumardi,* spp.; middle, *Desmoceras* (two species); base *Hamites fremonti, comanchensis, Pliotoxaster.* Exposed about	20
F.	White, shelly limestone, a Gryphea shell conglomerate: *Gryphea corrugata, tucumcari, Hamites*	2
E-	Brownish-yellow clay; *Exogyra texana, Gryphea corrugata*	5
D.	Brown limestone; *Exogyra texana, Tylostoma* (large); about	5
C.	Brownish calcareous clay and limestone in alternate thin layers; *Oxytropidoceras supani* (large), *Tylostoma* (large), *Exogyra texana, Gryphea marcoui, Protocardia*	10+

CENOZOIC AND RECENT

No continental tertiary deposits, such as are known on the High Plains farther north, have been found near Fort Stockton. Nor have any undoubted Pleistocene deposits, or any Pleistocene fossils been found here, so far as the writer can definitely discover. Large springs have existed here since before the Pleistocene and it seems likely that animals would have congregated near them and that fossil remains may be found. The uplands are of the stripped plain type; they have undergone denudation for a considerable period, and under these conditions, unconsolidated deposits of gravel, clay and sand would have little chance to escape removal, except perhaps locally. Around Comanche Springs there are thin deposits of semi-consolidated gravels, which may be Pleistocene or Recent. I can find no records of their having yielded fossils so far.

Pleistocene fossils have been found in adjoining counties. In 1926 portions of a young elephant were found in the detrital material about a mile north of Alpine. Judge O.

W. Williams states that about twenty years ago mastodon bones were found in the two localities, one of them 10 miles southeast of Monahans, Ward County, in a well 20 feet deep. Elephant tusks were reported to have been found in 1925 in two localities, near Orla, Reeves County. One locality was on the railroad about two miles northwest of Orla, and the other was about twelve miles west of Orla, just across the Culberson County line. These records are from Mr. Dunlap of Austin. Recent deposits in the Fort Stockton area consist of soil, sand, gravel, caliche and travertine. The first named materials form the valley fill, nowhere very deep, and the thin mantle over the pediments, which lie at the foot of the uplands and cuestas and surround the mesas. Caliche is found generally in the region under favorable conditions. Fairly thick caliche and caliche-conglomerate is found locally east of Twelve Mile Mesa. Some travertine blocks and incrustations may be seen in the stream west of Seven Mile Mesa and elsewhere.

STRUCTURAL GEOLOGY

The quadrangle has a thin veneer, maximum about 600 feet, of Lower Cretaceous sediments, sand, marl, and soft limestones, which were deposited over thick Permian (and Triassic) rocks, and which later have been partly removed. The Comanchean, the Triassic and the Permian are all separated by unconformities, since between each of these systems there was a period of denudation. The data at hand are not sufficiently reliable or extensive to clarify the exact stratigraphic relations of these systems. Samples from most of the 150 or so wells drilled in Pecos County are not available for examination, and the records of formations encountered, and even of depths and elevations are frequently conflicting and unreliable. For this reason no contour maps have been attempted, but the available data have been tabulated.

Surface Structure: The quadrangle is too extensively dissected into outliers for the *Desmoceras* horizon to be a

valuable marker. However, a table of elevations of its outcrops is given. The top of the basement sand is a widely recognized marker in this county, and the number of records of its occurrence could be greatly increased. This would doubtless provide the best obtainable Cretaceous marker. It would be of especial value to know the elevations of numerous water wells in western Pecos County and elsewhere.

The basal formation of the Comanchean shows two features of structural interest. (1) A contour map of its top exhibits certain pronounced areas of high structure. One of these is in eastern Pecos County, and may be outlined by running profiles from the group of Sherbino wells (Section 41, 51 of Block C-4) northwards to the White and Baker 1, Gulf (85:194), northeastwards to the Perry wells, and southwards to the Corder (51:2) and the Blackstone and Slaughter (11-T) wells. The top of the basal sand dips more steeply off the south side of this nose than to the north or east. Near Fort Stockton some structural relations are seen, but there are not sufficient data available to construct a good structure map. At the west end of Twelve Mile Mesa the top of the sand lies around 3317–3329 feet, and from here dips north or northeast. The sandstone outcrop southeast of the east end of Seven Mile Mesa has an elevation of about 2848 to 2855–60 feet, varying with locality, according to Mr. H. L. Baldwin; the outcrop near the northwest point of the same mesa has an elevation of about 2860 feet. These are the only exposures in, or near, the quadrangle. Elevations of the outcrop near the old shallow oil field by Mr. Baldwin, are given on another page. Well records on the top of the basement sand, as on the top of the Red Beds, indicate a flattened area just northeast of Fort Stockton, which is in contrast to the underlying Permian structure, as is shown by the deep lime in the Pinal Dome well. There is likely a local ridge in the top of the basement sands running north from the Pinal Dome well through the shallow oil field and Section 592, but the wells to the west do not delimit this feature sufficiently. (2) There are indications that the Comanchean sea invaded some

areas (as 89.OW) earlier than others, and that locally the base of the basement sand is thickened *(Chara* beds). A record of wells which contain these thickened basal Comanchean sediments is given on page 33.

Red Beds: (a) Near Fort Stockton. Wells in Fort Stockton record considerable Red Beds. The Fort Stockton waterworks well has 265+ feet, and the Quinby Townsite well 915 feet of Red Beds (1647 feet of Red Beds series above the top of the salt). North of town the Pinal Dome well has 1383 feet of Red Beds, the Thomas 5 well 858 feet (1208+? feet of the series) the Histed well (Section 210) has 910 feet, and various wells on Section 18–19, Block 140, record Red Beds (Oregon-Tex., 100 feet; Dupont 1, 282 feet, Polk Prospecting Company various thin beds between 56 and 259 feet); on Section 602 the Tyrell well has 49 (?) feet; on Section 592 the Bennett 2 has an unknown amount of Red Beds above 302 feet depth, the water well is stated to have 25 feet of Red Beds; and on Section 591 the Gray 1 (Adams Oil Company) has an unknown amount between the depths of 85 and 405 feet. Other wells in 19:140, as the Trans-Pecos No. 1 and the Old Turney well record no Red Beds. The Red Beds are found farther north, near the Pecos River. The southernmost available records in the Fort Stockton quadrangle are the Luce and Odom wells; the Red Beds disappear between here and the Sierra Madera. West of Fort Stockton they are present in Section 89, Block OW (795 feet) and in the Hershenson (Dixie) well (940 feet; 2290 feet for the series).

To the north of Fort Stockton there is a well defined high on the top of the Red Beds; in the Thomas well, this surface is at 2330 feet altitude; in the Pinal Dome well at 2519 feet altitude, and in University 1 (Buell and Hagan) at 2346 feet altitude. This high seems to extend as far north at least, as Section 592.

(b) Eastern Pecos County: Like the other shallow formations, the top of the Red Beds shows a broad east-plunging nose, with a high point in the neighborhood of the Sherbino wells. In the Sherbino (Dixie) it has an altitude of 2346 feet, and in other wells to the south, east, and north

a less altitude (Corder, 1935 feet; Noelke, 1988 feet; Perry-Plymouth, 1863? feet; White and Baker-Texas Top, 2133 feet; White and Baker-Gulf, 2233 feet). In the absence of good data it is not advisable to attempt a detailed contour map. In addition, since the Red Beds were followed by a long period of emergence, this surface is an erosional (topographic) feature, and its value for indicating structure very debatable. Details are included here for comparison with the top of the basement sands, and with the underlying Permian markers.

Salt: The depths for the top surface of the salt are more reliable than the lime-points, especially in older wells. The top of the salt is generally located in logs. Complete data for recent wells in eastern Pecos County are not available to the writer and therefore details of the salt cannot be presented for this region. Near Fort Stockton many of the wells did not reach the salt, and in some of these the salt is undoubtedly missing. The salt, where present, rises in altitude northwards from Fort Stockton; in the Townsite well it occurs at 2022 (=945 altitude) and in the Pinal Dome well at 1655 (=1136 altitude), while in the California Cordova well it is found at 834 (=1781 altitude). In the Thomas well, the wells in Section 602, in Sections 591 and 592 and in the old shallow oil field, no salt records were found. Likewise in the University 1 (Bower, Hale and Lamb) and University 1 (Buell and Hagan) no salt was recorded. Other wells south and just west of Fort Stockton do not furnish data sufficient to outline the areas of occurrence of salt. The salt is scattered over about 700 feet in the Pinal Dome well, but in the Townsite well it aggregates a smaller thickness which is scattered over about 300 feet. In this region the salt is evidently disappearing to the north and west. Thus, north of a line between these two wells, the salt does not afford means of determining the structure. The salt, like the top of the lime, rises to the northeast of Fort Stockton, as the above mentioned wells show. Farther to the west, the Hershenson (Dixie) well has a large thickness of salt aggregating about 1150 feet.

In Eastern Pecos County: The top of the salt, like the Red Beds and the basal Cretaceous sand, forms a broad general east-plunging nose, whose details, however, are much modified in the region of the Yates field. The McKenzie well (Section 8, Block 604) is reported to show salt at an altitude of 2018 feet. The Sherbino wells show it around 1896 feet; the Perry wells at altitudes ranging from 1796 to 1873 feet. It drops to the south (Harral well, 1834 feet; Corder well, 1590 feet, altitude). Structural conditions and possible subsequent erosion have complicated the altitude of the top of the salt in the river strip (I.G.N., Block 1), where available data are insufficient to make a good contour map.

The economic bearing of the salt deposits is discussed on pages 99–100.

Lime: The samples of most of the earlier wells are not available, and consequently the writer does not have reliable data on the lime points in most Pecos County wells. In the absence of dependable horizon markers in well cuttings from these limestone formations there has been widespread disagreement regarding the top of the lime in this county. This is reflected in the available records. Nor is it known that the top of the "lime" is everywhere the same horizon. Correlations of the Noelke well, made by Dr. Udden, are given on page —; there it is seen that of the limestones coming just under the Red Beds, those from 2140 to 2290 feet correspond to the Vidrio formation, and those from 2340 to 3050 feet to the Word. In the Sherbino (Menzie) well, the samples from 2640 to 3740 feet are correlated with the Vidrio and Gilliam formations. These correlations would relegate the bulk of the Salt Series and Red Bed Series of these two wells to the highest Permian formations of this region. However, it is not known, on passing northwards towards the Salt Basin, whether and to what extent the Glass Mountains section progressively passes over into a Salt Basin facies, and therefore whether the top of the "lime" is contemporaneous throughout the area under discussion. Certain lime points are here listed, but no attempt has been made to contour the top of the lime. The

top of the lime is taken at slightly different horizons by different workers. No attempt is made to decide between these various interpretations, but the sequence of beds near the top of the lime series in different wells will be seen in the accompanying sample descriptions.

Sands in the Lime Series: Near the top of the lime series in Pecos County, there is a widespread series of sand beds, which appears to have some value for correlation. Determination of the exact lime point in the Noelke well seems uncertain, for the reason that this well recorded a large aggregate thickness of sands at various levels, which have been correlated with the Vidrio, the Word and the Leonard formations. These sands are mainly as follows:

Noelke 1: 2125 (in Red Beds); 2135–2150 (Vidrio, Udden); 2465, 2530–2540, 2570–2580, 2630–2640, 2660–2690, 2730, 2745, 2875–2885, 2905 (Word, Udden)
Corder 1: 2000–2020, 2075–2120, 2135–2165
Blackstone & Slaughter 1: sand logged below 2770
Harral 1: sand logged below 2620
White & Baker (Gulf): 2545–2555
White & Baker (Texas Top): 1304–1312, 1433–1440, 1486–1496, 1610–1630, 1660–1725, 1740–1750, 1760–1770, 1807–1840, 1884–1890
Sherbino (Menzie): 2296–2307, 2327–2368, 2500–2545, 2840–2855, 2938–2953
Perry (Plymouth): 1905–1945, 2030–2055, 2110–2125, 2830–2410, 2815–2860, 2970.
Devlin 1 (Pinal Dome): 3325–3390
Bennett 2: 1170–1230, 1225–1260, 1265–1270

Tabulated Elevations on Key Horizons: The following are elevations on various horizons in Pecos County.

Top of Democeras Bed (Basal Duck Creek Limestone)

Elev.	Block	Sect.	Location
2875	114-GCSF	6	Hill 2903, west of Grandfalls road.
2900	119-GCSF	4	Hill 2925, at turn of Buenavista road.
3000	5-TC	8	Seven Mile Mesa, northeast corner.
3075	5-TC	13	Seven Mile Mesa, northeast corner.
2970?	(est.)	204	Comanche Spring.
3025	OW	92	Leon Spring.
3150	200	1	Five Mile Mesa, west end, opp. Sachse R. H.
3200	118-TStL	14	Five Mile Mesa, east end.
3516	3-TP	143	Twelve Mile Mesa, west end.

Elev.	Block	Sect.	Location
2900	114-GCSF	3	Needle Point.
3400?	134-TStL	19?	Round Mountain.
3250?	51-TP	6	(twp. 10) Near Hershenson Well.
?	3-TP	117?	Triple Hill.
2675?	112-TC	4	Butte.
3175	28-UT	30?	Hill 3175, Five Mile well.
2950?	24-UT	29	Butte 3038.
?	16-UT	Sw-cor.	White Butte, 35.4 miles east of Fort Stockton.
2700?	105	1	4 miles west of Devlin R. H.
3000	118	19	2.7 miles east of Five Mile Mesa.
3025	.....	....	1.3 miles east of Leon Reservoir.
?	24-UT	7, 16	North of Sheffield Road.
2953	24-UT	33	University Mesa, notch in north side.

Basal Cretaceous Sand

	Well:	Elev.	Top of Sand Depth	Top of Sand Elev.	Thickness of Basal Sand
45	Montgomery	3000	370?	2630?	?
66	C. Raulins	3010	300	2710	?
74	Townsite (Quinby)	2967	252	2713	123
20	Fort Stockton City Waterworks	2967	259	2708	116
73	Thomas	2877	270	2607	277
1	Artesian well, Section 623	2809	192?	2617?	?
32	Histed	2726*	105	2621	275
80	University 1 (Buell and Hagan)	2816	150	2666	320
79	University 1 (Bower, Hale&Lamb)	2667	30?	2637?	170?
14	Devlin 1 (Pinal Dome)	2791	121	2670	151
12	Davenport (Leon Spring)	3055?	193	2862	116
36	H. Lawrence	3000?	250?	2750?	?
53	Pecos County 5	2970	290	2680	?
71	Batchelor 1 (S.W. Life 89:OW)	3136	220	2916	460
40	Leon Spring	3010	171	2839	?
	Leon Spring 4	2995	104	2891	218
6	Blackstone and Slaughter 1	2856	565	2291	115
83	White and Baker (Gulf)	2993	630	2363	130
84	White and Baker (Texas Top)	2583	231	2352	219
68	Sherbino (Dixie)	2871	340	2531	185
69	Sherbino (Menzie)	2858?	320	2538?	185
70	Sherbino (Transcontinental)	2820?	312	2508?	203
46	Noelke (Reilly)	2248	163	2085	97?
29	Harral (Circle O.C.)	2854?	320	2534?	185
11	Corder (Beth Tex)	2630?	512	2118?	183
30	Hershenson (Dixie)	3282	255	3027	165

Well:	Elev.	Top of Sand Depth	Top of Sand Elev.	Thickness of Basal Sand
62 Perry 1 (Transcontinental)	2643	260	2383	145
63 Perry 1 (Plymouth)	2563?	212	2351?	488?
64 Perry 3 (Republic)	2591	252?	2339?	68?

Outcrops of Basal Cretaceous Sand

Elevation Top of Sand[43]	Blk.	Sect.	Remarks:
2500?	8–HGN	106	South end of reservoir; steep south dip.
2597	10-HGN	9	Northwest corner of section.
2602	10-HGN	9	West corner.
2628	112-TC	6	Center of section.
2650	112-TC	4	Center north one-half.
2663	105	4	Southeast corner; 45 feet in well.
2561	140-TStL	20	Southeast corner.
2585	140-TStL	17	Center.
2850?	5-TC	17	One mile S21E of east tip, Seven Mile Mesa.
3317–3329	3-TP	142	West end, Twelve Mile Mesa.
2759	26-Univ.	6	One mile north of University Mesa.

Red Beds

Well:	Elev.	Top of Red Beds Depth	Top of Red Beds Elev.	Thickness of Red Beds Proper Series
2 Belding	3200?	315+	?	
3 Bennett 1	2564	340?	2224?	?
4 Bennett 2	2562	302	?	?
6 Blackstone and Slaughter	2856	680	2176	405
11 Corder	2630	695	1935	345
12 Davenport	3055?	309	2746?	?
13 Devlin (Adams)	2529	160?	2369?	?
14 Devlin Pinal Dome)	2791	272	2519	1383
15 Devlin (Smith)	2538	186?	2352?	
17 Dupont 1	2578	48	2530	282
20 Ft. Stockton City Wtrwks	2967	375	2592	265+
27 Oregon-Texas	2598	61	2537	100
28 Gray (Adams)	2557	85	2472	?
29 Harral	2854	505	2349	515

[43]Most of these elevations were kindly furnished by Mr. H. L. Baldwin.

	Well:	Elev.	Top of Red Beds Depth	Elev.	Thickness of Red Proper	Meds Series
30	Hershenson (Dixie)	3282	420	2862	940	2290
32	Histed	2726	380	2346	910	
41	Luce	3382?	293	3089?		
42	Macy	2540	86	2454		
46	Noelke	2248	260	1988	330	
47	Odom	3190	340	2750?		
62	Perry 1 (Transcontinental)	2643	405	2238	365	
63	Perry 1 (Plymouth)	2563	700	1863?	10?	
64	Perry 3 (Republic)	2591	320	2271?	480?	
67	Rooney 1	2695?	56	2639?		
68	Sherbino (Dixie)	2871	525	2346	455	
69	Sherbino (Menzie)	2858?	505	2353?	457	
70	Sherbino (Tr'nscontinental)	2820	615	2205	309	
71	Southwestern Life	3136	680	2456	795	
73	Thomas	2877	547	2330	858	1208+
74	Townsite (Quinby)	2967	375	2592	915	1647
75a	Trees	2545	525?	2020?		
76	Troy	2568	112?	2456?		
78	Tyrell	2667	68	2599		
79	University 1 (Bower, Hale & Lamb)	2667	200	2467	70?	
80	University 1 (Buell and Hagan)	2816	470	2346	330?	
81	Water well (Section 592)	2552	335	2217		
83	White and Baker (Gulf)	2293	760	2233	295	
84	White and Baker (Texas Top)	2583	450	2133	262	945

Salt

	Well:	Elev.	Top of Salt: Depth	Elev.
6	Blackstone and Slaughter	2856	1085	1771
11	Corder	2630	1040	1590
14	Devlin (Pinal Dome)	2791	1655	1136
29	Harral	2854	1020	1834
30	Hershenson (Dixie)	3282	2710	572
46	Noelke	2248	595	1653
62	Perry 1 (Transcontinental)	2643	770	1873
63	Perry 1 (Plymouth)	2563	710	1853
64	Perry 3 (Republic)	2591	795	1796
68	Sherbino (Dixie)	2871	980	1891

	Well:	Elev.	Top of Salt: Depth	Elev.
69	Sherbino (Menzie)	2858?	962	1896?
70	Sherbino (Transcontinental)	2820	824	1896
74	Townsite (Quinby)	2967	2022	945
83	White and Baker (Gulf)	2993	1055	1938
84	White and Baker (Texas Top)	2583	714	1869
86	Manly Holmes 1	2507	640	1867
87	McKenzie 1	3188*	1170*	2018
88	Blackman Scharff 1	2402	890	1512
89	Cordova Union Fee (California Co.)	2615	834	1781
90	Yates 1 (G. A. Henshaw & Co.)	2250	525	1725
92	Yates 2 (Texon)	?	430	
94	Rheinstrom 1 (Humble-Kirby)	2351	830	1521

Lime

	Well:	Elev.	Top of Lime Depth	Elev.
4	Bennett 2	2562	1270?	1292?
6	Blackstone and Slaughter	2856	1900	956
7	Buenavista	2360	1400*	960
11	Corder	2630?	1970?	660?
14	Devlin 1 (Pinal Dome)	2791	3245?	–454?
29	Harral	2854	1815?	1039?
30	Hershenson (Dixie)	3282	5200?	–1918?
46	Noelke	2248	2150?	98?
62	Perry 1 (Transcontinental)	2643	1220	1423
63	Perry 1 (Plymouth)	2563	1520?	1043?
69	Sherbino (Menzie)	2858?	2307?	551?
75a	Trees	2545*	2875*	–330
76	Troy 1	2568	1096?	1472?
74	Townsite (Quinby)	2967	3190?	–223?
79	University 1 (Bower, Hale & Lamb)	2667	1260?	1407?
80	University 1 (Buell & Hagan)	2816	1935*	81
83	White and Baker (Gulf)	2993	2470*	523
84	White and Baker (Texas Top)	2583	1312?	1271?
85	Yates 1 (Mid Kans.-Transc.)	2398	970*	1428
93	Yates 3 (Mid Kan.-Transc.)	2379*	992*	1387
64	Perry (Republic)	2591	1235?	1356?
99	Blackman 1	2402*	2055*	347
100	Cordova Union Fee	2615*	1442?	1173

RECORDS OF PECOS COUNTY WELLS

Unless otherwise stated, location is given by two numbers representing section and block: e. g., 19:140 means section 19 of block 140, Pecos County. Asterisk indicates figures taken from trade journals, mainly the Oil Weekly.

Well and Location:	Elev.	T.D.	Top B.S.	Top R.B.	Top Salt	Top Lime
1 Artesian well (Survey 623)	2809	192?	192?			
2 Belding (Arnett, Crawford & Williams; 100-3TP.)	3200?	456		315+		
3 Bennett 1 ?=Grant 12 (592:105)	2564	1025		340?		
4 Bennett 2 (Quinby; 592:10')	2562	1457+		302—		1080?
6 Blackstone and Slaughter 1 (Ark. Fuel O.C.; 11:T)	2856	3395	565	680	1085	1900?
7 Buenvista (U.S.-Mex. Trust Co.; 23:2 HTC)	2400*	1414				1400*
8 Calumet and Arizona (junked; =C; 19:140)	2578	51				
9 Calumet and Arizona 1 (=D; 19:140)	2578	550				
10 Calumet and Arizona 2 (=E; 19:140)	2578	576				
11 Corder (Beth-Tex: 51:2)	2630	3405	512	695	1040	1970?
12 Davenport (Leon Springs)	3055?	451	193	309		
13 Devlin (Adams O. C.; 3, Ashmore)	2529	1004		160?		
14 Devlin (Pinal Dome; 208, Burleson)	2791	3955	121	272	1655	3245
15 Devlin (Smith; 3, Ashmore)	2538+	1313	?	186?		
16 Downie 1 (S.R. Legon Co.; 18:R4)	3050?	1170+	245?	none		
17 Dupont Powder Co. 1 (18:140)	2578	341		48		
18 Dupont Powder Co. 2 (=B; 19:140)	2578	428				
19 Edwards water well (48:OW)	?	166	122?			
20 Fort Stockton City Water Works (=Metcalf 1 ?)	2967	642	259	375		
21 Grant 4, "Wonder Well" (=F; 19:140)	2585	51				

Well and Location:	Elev.	T.D.	Top B.S.	Top R.B.	Top Salt	Top Lime
22 Grant 7 (=G; 19:140)	2578?	131				
23 Grant 8 (=H; 14:140)	2578?	213				
24 Grant 9 (?=I; 19:140)	2578?	78				
25 Grant 10, "Miracle Well" (=J; 19:140)	2578	96				
26 Grant 11 (=K; 19:140)	2578	160				
27 Grant 6 =Oregon-Texas (19:140)	2598	2200+		61		1015?
28 Gray 1 (Adams O. C.; 591)	2557	1133		85		
29 Harral (Circle; 25:127)	2854	3951	320	505	1020	1815
30 Hershenson 1 (Dixie; 6:51, twp. 10)	3282	5354	255	420	2710	5200?
31 Hershenson 1 (Droppleman; 7:51, t. 10)	3254	3665*			2640*	
32 Histed (S. W. Pet. Co.; 210:210)	2726	1490	105	380	?	
33 Honey 1 (Leon Springs)	3000?	316	165			
34 Ink Ranch (114:8 H.G.N.)	?	650				
35 K. C. M. & O. (Redlands)	?	307				
36 H. Lawrence Water Well (Section 502)	3000?	254	250?			
37 Leon Spr. Irrig. Co. 1 (McSpadden)	3000	322	131			
38 Leon Spr. Irrig. Co. 2	3000	72				
39 Leon Spr. Irrig. Co. 3	3000	60				
40 Leon Spr. Irrig. Co. (105:OW)	3010?	448	171			
41 Luce Well	3382?	1000	?	293		
42 Macy 1 (Lloyd & Miller; 29:10)	2540	1070		86		
43 Maull 1 (Batchler 1; 89:OW)	3136?	446?	?			
44 Montgomery (Alexander Synd., 6:1, G.C.S.F. Ry.)	?	1670				
45 Montgomery Water Well	3000	404	370?			
46 Noelke 1 (Reilly-Texas Acreage Co., 4:193)	2248	3206	163	260	590	2150?

Well and Location:	Elev.	T.D.	Top B.S.	Top R.B.	Top Salt	Top Lime
47 Odom 1 (Sou. Sta. Prod. Co.; 108:3)	3190*	1205*		340		
48 J. W. Patterson Water Well	?	23				
49 Pecos Co. 1 (10:48, twp. 10)	?	60				
50 Pecos Co. 2 (43:OW)	?	80				
51 Pecos Co. 3 (8:48, twp. 10)	?	58				
52 Pecos Co. 4 (19:140)	?	341				
53 Pecos Co. 5 (Old Orient Sta.)	2970	370	290			
54 Pecos Co. 7 (near Block 114)	?	118				
55 Pecos Co. 8 (2:OW)	?	300				
56 Pecos Co. 9 (43:OW)	?	930				
57 Pecos Co. 10 (10:48, twp. 10)	?	157				
58 Pecos Co. 11 (8:48, twp. 10)	?	40				
59 Pecos Co. 12 (6:48, twp. 10)	?	180				
60 Pecos Co. 13 (23:2)	?	342				
61 Pecos Co. 14 (19:140)	2571	1201	(See No. 28)			
62 Perry 1 (Transc., 5:Z)	2643	3634	260	405	770?	1950?
63 Perry 1 (Plymouth; 30:178)	2563?	2990	212	700	710	1520?
64 Perry 3 (Republic; 6:Z)	2591*	2365	252?	320	800	1235?
65 Perry (Four Mile Canyon; 4:Z)	?	3260?				
66 C. Raulins Water Well (Section 502)	3010	317	300			
67 Rooney 1 (Polk Prosp. Co., 18:140)	2682*	1218		56		
68 Sherbino (Dixie; 51:C4)	2871	1742	340	525	980	?
69 Sherbino (Menzie; 51.C4)	2858?	3745	320	505	962	1534?
70 Sherbino (Transc., 41:C4)	2820	1701	312	615	924?	?
71 Southwestern Life 1 (Buell and Hagan, 89:OW)	3136	2740	220	680	none	?
72 Stockton Hotel Water Well	2970	100?				

Well and Location:	Elev.	T.D.	Top B.S.	Top R.B.	Top Salt	Top Lime
73 Thomas 1 (Trans-Pecos 5, 6:114)	2877	1825	270	547		
74 Townsite (Quinby, 254:267, Orient)	2967	3440	252	375	2022	3190?
75 Turney 1 (Trans-Pecos, =L; 19:140)	2578	2835	65			
75a Trees Well (50:8, H.G.N.)	2545*	3115+	345	525		2875*
76 Troy 1 (20:140)	2568	2997		112?		1096?
77 Old Turney Well (=A; 19:140)	2578	1200	?	?		
78 Tyrell (Ft. St. Synd., 602, Fall)	2667	1165		68		
79 University 1 (Bower, Hale and Lamb, 24:26 U.T.)	2667	1700		200	none	1260?
80 University 1 (Buell & Hagan; 31:24, U.T.)	2816	3008	150	470	none	1935*
81 Water Well (Section 592)	2552	995		335		
82 Western Pet. Co. (Section 209)	?	1480		?		
83 White & Baker (Gulf; 85:194)	2993	4280*	630	760	1055*	2470*
84 White & Baker (Texas Top; 11:Z)	2583	3225	231	450	714	1312?
85 Yates 1 (Mid-Kans., Transc.; 60:1, I.G.N.)	2398?	1003+		none	none	970*
86 Yates 1 (Henshaw; 342:1)	2250*	1510+			525*	
87 Yates 1 (Texon; 55:1)	2250*					
88 Yates 2 (Texon; 65:1)		1096+				
89 Yates 3 (Texon; 63:1)	Loc.*					
90 Yates 1 (Kimberlin and Pickrell)					460*	
91 Yates A-1 (Mid-Kans. Transc.)		1033*				
92 Yates A-2 same		1001*				
93 Yates A-3 same		1078*				
94 Yates A-4 same		715*				
95 Yates B-1 (Mid-Kans. Transc.; 61:1)		1243*				
96 Yates C-1 (Mid-Kans. Transc.; 60:1)		858*				

	Well and Location:	Elev.	T.D.	Top B.S.	Top R.B.	Top Salt	Top Lime
97	Holmes 1 (Ark. Fuel O.C., 16:178 TC)	2507*	2020*			640*	
98	McKenzie 1 (Buell & Hagan; 9:604)	3188*	1660*			1170*	
99	Blackman 1 (Kimberlin & Cromwell; 24:3 H.T.C.)	2402*	2126*			890*	2055*
100	Cordova Union Fee (Calif.; 10:141 TC)	2615*	1850*			834*	1442*
101	Rheinstrom (Humble-Kirby)	2351*				830*	
102	J. T. McElroy (Kirby-Humble; 124:10)		735+*				
103	Blakesley 1 (Marland-Texon; 90:11)		1070+*			840*	
104	Smith Taylor 1 (Mid-Kans. Transc.; 33:194)		642*			----	
105	Patterson & Fultham, K.C. Ft. St. 1 (19:178)		520*				
106	Gray (Quinby; 593:105)		660*				

ECONOMIC GEOLOGY

WATER

Water is the most important mineral resource in the county. Underground water occurs mainly in two reservoirs, the Basal Cretaceous Sand, and the Permian. Utilizable water is derived from wells, springs and rainfall (tinajas, charcos). Some Pecos County waters carry salt, potash, sulphur and other chemicals.

Water from Basal Cretaceous Sand ("Trinity"): This is the most widespread water horizon in the county. Since much of the county has middle Washita beds at the surface, the top of the sand is reached at a depth of about 300 feet. The basal Cretaceous water is very different in western Pecos County and in the Fort Stockton quadrangle. West of about the meridian of Leon Springs this water is uniformly of excellent quality. East of Leon Springs and the Grandfalls road and south of the basal sand outcrop, this water, although suitable for domestic uses, carries a greater amount of mineral salts. North of the basal sand outcrop, the Permian or the Triassic is near the surface, and the water is derived from these formations. It is a gypsiferous or saline or sulphur water. These facts suggest that from east to west some factor has appeared which protects the basal Cretaceous water from contamination. Since westwards it is relatively uncontaminated, we may assume that its base is here protected by an impervious layer, possibly of clay, whose exact age is unknown. Farther east this protection for some reason is absent. The following factors may be considered: (1) Any impervious layers beneath the basal sands may be irregularly developed, or absent locally. (2) A fissured or faulted condition of the underlying beds may locally permit a contamination of the Cretaceous water from beds of the Permian Salt Series. It is noteworthy that analyses of waters from Comanche Springs and from shallow wells near Fort Stockton reveal nearly complete identity. The area of poorer Cretaceous water coincides with the locations of large springs, Leon, Comanche, Monument, Santa

Rosa, Tunas, Salado and others. Some writers consider these to be fissure springs.[44] There is evidence to support the assumption of widespread subsurface fissured conditions in this region: erratic surface dips, the behavior and the drilling conditions of wells, sudden large flows of water, caverns actually encountered, water analyses, and temperature data. In time the walls of these solution channels would become leached and permit the passage and solution of only moderate amounts of mineral salts. If new outlets are created by drilling, they disturb the water levels and relations in outlets from the same channel. (3) The subsurface extent of the Triassic roughly coincides with the area of poorer Cretaceous water, and may affect the composition of this water.

Rainfall Data and Catchment Area: The catchment area of the basal Cretaceous sands is located around the Sierra Madera (elevation about 3800 feet), in an area south and southwest of Belding (elevation 3200–3300 feet) and in Reeves County north of the Hershenson well (elevations of around 3200 feet). The total extent of this outcrop has not yet been measured, but is probably less than 50 square miles in this vicinity. From the two localities first named the rocks dip north to northeast towards the Fort Stockton quadrangle, and from the Hershenson well they dip in a general easterly direction.

The recorded station nearest the catchment area is Fort Stockton; for reference, other nearby stations in the plains and in the mountains are given. At Fort Stockton a mean annual precipitation of 15.22 inches is recorded for the period 1870–1920.

MEAN ANNUAL RAINFALL
(United States Weather Bureau)

Dates:	Fort Stockton	Barstow	Grandfalls	Balmorhea	Fort Davis
1855–1920	----	----	----	----	17.17
1870–1920	15.22	----	----	----	----
1904–1919	----	10.64	----	----	----
1921 (total)	10.32	----	----	----	10.10
1922 (total)	12.11	----	----	----	----
1923 (total)	18.83	----	12.86	----	18.17
1924 (total)	9.82	----	----	9.11	----
1925 (total)	20.43	----	11.04	14.65	16.65
1926 (total)	18.32	----	15.59	18.31	----

[44]Baker and Bowman, Univ. Texas Bull. 1753, p. 131.

Northern Pecos County: Water occurrences in wells in this part of the county are discussed in the section on well records. The Permian waters are from the Salt Basin Series, and are salty, gypsiferous, or sulphur waters. Some of the largest sulphur water wells in Texas are situated near Fort Stockton. The Old Turney well (Section 19, Block 140) now flows about a cubic foot per second. (One cu. ft. per sec.=646,272 gal. per day.) Mr. Baldwin estimates that the nearby "Miracle Well" flows about ¼ cu. ft. per sec., and that this whole group of abandoned wells in the old shallow oil field (Section 19, Block 140) is now discharging about 3 cu. ft. per sec. The Trans-Pecos No. 3, on the same block and section flows about 4 cu. ft. per sec., forming a rapidly cutting stream which after a mile or so disappears by seeping into the ground. Trans-Pecos No. 1 (on 19:140) is supposed to flow nearly 2 cu. ft. per sec., and Trans-Pecos No. 4 (on 20:140) was originally a smaller well, but is now cemented off.

Comanche Springs combined (elevation 2925) are stated to have a flow of 50–60 cu. ft. per sec. The latter figure amounts to around 38,775,000 gallons per day; however, figures as high as 66,000,000 gallons per day have been claimed. The discharge of Leon Spring is stated to be one-fourth or one-fifth that of Comanche Springs. Analysis of Comanche Springs water is given on a later page.

The United States Geological Survey gives the following measurements of Comanche Springs:* Summer 1899, 66 second-feet; July 26, 1904, 64 second-feet; August 21, 1919, 44 second-feet; April 8, 1922, 46 second-feet; October 22, 1922, 42 second-feet.

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*O. E. Meinzer: Large Springs in the United States. U. S. G. S., Wat. Sup. Paper 557, 1927, p. 41. T. U. Taylor, The Water Powers of Texas. U. S. G. S., Wat. Sup. Paper 105, 1904, p. 15.

PECOS COUNTY WATER WELLS

Name	Block	Sect.	Elev.	T. D.	Qual.	Amt.	Water stands[45] Feet	Remarks:
TC 5	12			280	av.	mod.	150	
TC 5	4			75	bad	abund.	30	
TC 5	14		2800	300	G	abund.	50	"Trin" sand at 40–2760
TC 5 ?FtStLd	16	(below Shef. rd).	2880	600 (628)	bad		75 (31?)	Sand at 100–2780
TSL 188	16		2967	280	G		100 (60?)	Starts top Kki
FtStIrrL 2	6	(tract 23)		300			4	Sand at 200
FtStIrrL 2	G			30			4	Surface water
Univ 24	32			shallow	av.	mod.	?	
TC 112	8				gyp	weak	60–70	Water in white sand Gryphea small sp. at surface
8	114			360			130	R.B. and oil at 130 ft.
HGN 8	50	Trees well		370*	bad	abund.	345	Cret. water in sand
TSL 142	22				gyp		60	
HGN 8	36						116	
OW	48	Edwards well		166				Top B.S. at 122
OW	45	Old Boxby						
TSL 143	12				G		shallow	
OW	31	(W of) Dunlop					250	
OW	89	Dixie-Belcher 1	3075	260	G	abund.	225 250–260	In gravel In sand

[45]This figure refers to the distance from the mouth of the well down to the top of the water.

Ft. Stockton City Waterwork			2967	642	av.	abund.		80–85	Sand
								356–358	White sand
								495–570	light gray sdy sh.
								576–581	red water sand
								581–587	red sd., fresh water
								597–600	red sd., fresh water
TP 3		43	Cactus		380	G	was abund.	220	was abun; caved in
TP 3		82			400	G	abund.	150	
TP 3		81	Kennedy R.H.		200	G	abund.	150	
TP 3		80			208	G	abund.	118	
TP 3		165	Qualls		450	G	abund.	300	
TP 49		37	twp 10		400	G	abund.	180	
TP 49		48	twp 10 Odneal		280	G	abund.	150±	
	183	1	Matthews		350	G	abund.	150	
GHSA	11	44			606	G	weak	313	
GHSA	11	40			521	G	11 gal. per min.	521	water rose alm. none
GHSA	11	52			548	G	abund.	200	
	183	2	Big Samson		360	G	abund	150	
	183	4	Tanquay		380–400	G	abund.	?350	
TP 50		48	twp 10 Almonds		501	G	abund.	?301	
TP 1		6	twp 10 Hershenson		252	G	abund.	250–52	basal Cret. sand
GHSA	11	85			135		weak	60	
	11	99			641	NG	weak		Small amt. of strong sulphur water at 400; well abandoned.
	11	144	Bill Addison		525	G	abund.	498	Water struck at 519
	118	18	Open hole		50		weak		El. 2967. ?200 ft to BS=B.S. Est. 2767

ANALYSES OF WATER FROM PECOS COUNTY[46]

Parts per million:

	Comanche Spring[1]	Ft. Stockton City Well[2]	Trans-Pecos No. 5[2]	Well 20 miles N. Sheffield[1]	Perry Salt Well[1]	Pecos River (Pecos Co.)[1]
Sodium	287	244.4	160.6	1336.6		1774
Calcium	127.1	156.6	655	548	NaCl	721.6
					about 99½%	
Magnesium	54.6	45.4	205.3	262.1		373.1
Sulphites				808.5		
Sulphates	430.4	378.6	2255.0	2256.3		1814
Chlorides	384	350	208.0	2573.6		3678.8
Carbonates		134.4	115.2			
Bicarbonates	219.6			701.2		139
Fe, Al	6	12	4.0			
SiO^2	34	8.0	4.0	66.4		
Free Sulphur				40.4		
H^2S			27.2			
Total Solids	1440	1329.4	3607.1	8634.8	316888	10932

FOR COMPARISON, AVERAGE OF 10 TRINITY WATERS FROM CENTRAL TEXAS (R. T. Hill)

	Av. of 10 grains gal	Av. of 10 prts. mill.	Range grains gal
Sulphates	15.9	274.3	9–40
Carbonates	23.3	401.9	11–36
Total Solids	62.8	1083.3	31–107

For comparison of Trinity waters from central Texas, see Schoch: Univ. Texas Bull. 1814.

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[46]For Pecos County Analyses: Schoch, Univ. Texas Bull. 1814, pp. 162, 248–249. Nos. 2991–2998.

[1]Analysis by Bureau of Industrial Chemistry. University of Texas.

[2]The Fort Worth Laboratories, courtesy of the Southern Crude Oil Purchasing Co.

WATER ANALYSIS OF CITY WATER WELL, FORT STOCKTON, TEXAS[47]

Properties of Reaction per cent:		
Primary salinity		47.90%
Secondary salinity		31.82
Primary alkalinity		none
Secondary alkalinity		20.28
Per cent rSO4 in rSO4 plus rCL		44.80
Ratio RCO3 to RSO4		0.57
Constituents in parts per million:		
Sodium		244.4
Calcium		156.6
Magnesium		45.4
Iron and aluminum oxides		12.0
Sulphate		378.6
Chloride		350.0
Carbonate		134.4
Silica		8.0
Hydrogen sulphide		none
Total		1329.4
Reacting values in per cents:		
Alkalies—		
Sodium		23.95
Alkaline Earths—		
Calcium		17.65
Magnesium		8.40
Strong Acids—		
Sulphate (rSO4)		17.83
Chloride (rCl)		22.03
Weak Acids—		
Carbonate (rCO3)		10.14
Hypothetically combined as—	parts per million	grains per U.S. gal.
Calcium Carbonate	224.0	13.00
Calcium Sulphate	227.5	13.15
Magnesium sulyphate	225.0	13.05
Sodium Sulphate	56.9	3.25
Sodium Chloride	576.0	33.35

[47]This and the following analysis were kindly furnished by the Southern Crude Oil Purchasing Company. The analyses were made by the Fort Worth Laboratories.

WATER ANAYSIS OF TRANS-PECOS OIL CO., HELEN THOMAS NO. 5

Properties of Reaction per cent:	
Primary salinity	12.30%
Secondary salinity	80.96
Primary alkalinity	none
Secondary alkalinity	6.74
Per cent rSO4 in rSO4 plus rCL	88.80
Ratio RCO3 to RSO4	0.08
Constituents in parts per million:	
Sodium	160.6
Calcium	655.0
Magnesium	205.3
Iron and aluminum oxides	4.0
Sulphate	2255.0
Chloride	208.0
Carbonate	115.2
Silica	4.0
Total	3607.1
Hydrogen sulphide: 27.2 P.P.M.	
Reacting values in per cents:	
Alkalies—	
Sodium	6.15
Alkaline Earths—	
Calcium	28.95
Magnesium	14.90
Strong Acids—	
Sulphate (rSO4)	41.45
Chloride (rCl)	5.18
Weak Acids—	
Carbonate (rCO3)	3.37

Hypothetically combined as—	parts per million	grains per U.S. gal.
Calcium Carbonate	192.0	11.13
Calcium Sulphate	1968.0	114.30
Magnesium Sulphate	1016.0	58.90
Sodium Sulphate	80.5	4.67
Sodium Chloride	342.6	19.86

ANALYSIS OF WATER FROM TROY WELL

	Parts per million
Carbonate of lime	300
Sulphate of lime	2191
Sulphate of magnesia	986
Chloride of magnesia	125
Chloride of soda	1263

This analysis, made at A. and M. College, was supplied by Mr. Frank R. Campbell, of Fort Stockton, in 1921. The depth of this water is not stated. The following statements were sent in with the analysis: "Referring to the Troy well, Section 20, Block 140, T. & St. L. Ry. Survey, Pecos County, I have just received advice that no salt was found in that well to the depth of 2725 feet. The formation has been hard and soft limestone all the way. They have a large flow of water, of which the above is the analysis."

OIL AND GAS

The Turney well (Kinsella prospect) was drilled about 1900 on an old seep in Section 19, Block 140, situated 12 miles north and 7 miles east of Fort Stockton. The depth was 1200 feet; some oil was recorded at the depths of 160, 250–400, 600–610, 620–630, 640–665, 665–685, 960–975, 1005–1025, 1035–1050, and 1130–1200 feet. There are records of gas at 685, 1025, and 1050 feet. Dr. Udden has made the following notes on this well:

"This well was bored about the year 1900, and was reported flowing some water and yielding some oil and gas. On October 17, 1910, I visited the locality and saw that it contained some oil and gas was being given off. On September 14, 1917, it held some oil; and gas, which, when escaping, would burn. An analysis of oil from this well was made by the University Mineral Survey in 1901 and is as below:

"Color, very dark brown and opaque. Odor similar to that of Corsicana oil, but more viscous than this oil. Specific gravity at 71.6° F=0.920 (22.2B). Flash point not determined.

Fractions	By weight	Color
71.6° to 392°F	1.79	pale amber
362 to 455	347	pale amber
455 to 496.4	6.51	straw yellow
496.4 to 680	12.99	straw yellow
Above 680°F	27.02	brown; blue flourescence
Res.	45.54	black, viscous mass
Loss	2.68	

The Dupont Powder Company well No. 2 drilled in the same section about 1910, reported shows of oil at shallow depths and a pocket of gas at 400 feet. About 1915 the Calumet and Arizona Copper Company drilled three wells nearby, of which the first, junked at 51 feet, was stated to have about 2 barrels of oil; well No. 1, 5 barrels; and well No. 2 a show of oil and gas. In 1920 several wells struck oil and gas at shallow depths in Section 19, Block 140. Grant No. 4 ("Wonder Well") had an estimated initial production of 50 barrels at 51 feet, and Grant No. 10 ("Miracle Well") an estimated production of 1000 barrels at 96 feet. These and other smaller wells, after blowing in, shortly ceased flowing oil. At present about a half a dozen wells on this tract flow about 3 cubic feet per second of sulphur water, with some gas and small quantities of oil. Other nearby holes produce a small amount of gas, and some oil stands in the casings. A deeper hole, Trans-Pecos No. 1, 2835 feet, drilled in the midst of this group in 1923, had shows of oil at various depths, mainly below the shallow level, and now discharges around 2 cubic feet per second of sulphur water.

Ichthyol Well. The Calumet and Arizona Well No. 2 drilled about 1915, produced a heavy black oil from which ichthyol, a medicinal product is distilled. This oil (in 1926) may be dipped from this hole and a nearby one. It is reported that in 1922 two tank cars of this oil were shipped from Fort Stockton and sold at about $7.50 per barrel. This oil was formerly used locally for greasing windmills.

In the old shallow oil field,[48] the surface formation is the basal sands of the Comanchean, and the oil must have migrated up along a fractured or cavernous area from the underlying Permian beds. The large flows of sulphur water and the occurrence of beds of secondarily deposited native sulphur (see discussion of "Sulphur") indicates cavernosity and ascending channels. The field was notable

[48]Wallace E. Pratt, The present excitement at Fort Stockton, Texas. Bull. Am. Assoc. Petr. Geol., 5, 88–89, Jan.–Feb., 1921.

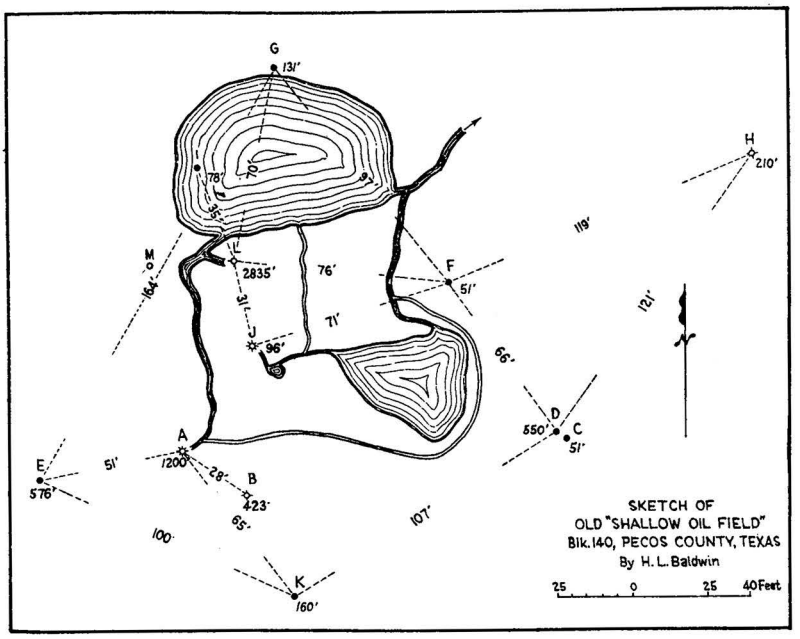

Fig. 8. Location of wells in old shallow oil field, sect. 19, blk. 140, T. & St. L. Ry., Pecos County, Texas (H. L. Baldwin).

A. Old Turney well (gas).
B. Dupont Powder Co. No. 2 (dry hole).
C. Calumet & Arizona (junked; 2 bbls.).
D. Calumet & Arizona No. 1 (5 bbls.).
E. Calumet & Arizona No. 2 (oil and gas show).
F. Grant 4 (Wonder Well; oil 50, water 500 bbls.).
G. Grant 7 (10 bbls.).
H. Grant 8 (dry hole).
I. Grant 9? (5 bbls.).
J. Grant 10 (Miracle Well, 1000 bbls., est.).
K. Grant 11 (oil show).
L. Trans-Pecos 1 (oil show).
M. Grant 9.

for its shallowness, and for the quickness with which the oil was followed by sulphur water, and in some of its features resembled the behavior of the Panuco field.

Other wells, as the Townsite, Bennett and Hershenson, have had oil shows. The Townsite well, at 3300 feet, struck a quantity of ozokerite, reported to be as much as two gallons.

Yates Oil Field: In November, 1926, the Mid-Kansas and Transcontinental's Yates No. 1, Section 60, Block 1, about 18 miles north of Sheffield along the river strip in Pecos County, came in for small heads of oil, 29.5° B., with a reported 2,000,000 feet of sulphur gas; depth about 992–997, reported elevation 2398 feet. The surface formation is near the top of the basement sands of the Comanchean, which are thin, since slate and limestone were logged below a depth of 110 feet. The production comes from a Permian lime on a pronounced structural high, the Salt Series and the Red Bed Series being absent. The Permian structure is indicated by overlying Comanchean structure, as at some other places in the middle Pecos Valley.

SALT

Thick masses of rock salt, penetrated in wells of the Fort Stockton region, are unable to compete on the market with other salt deposits of Texas because of their deep burial, and because of transportation costs and other market conditions. However, these salt brines may be made to yield a product of local commercial value. The Republic Production Company's Perry No. 3 well (Section 6, Block Z, about 27 miles southeast of Girvin) has a flow of brine which is evaporated in sun vats, and yields salt for the local market. Dr. E. P. Schoch has made the following comments on this brine.[49]

"Water sent by Frank A. Perry, Girvin, Texas, contains 316,888 parts of solids per million parts water. These solids contain less than one-half per cent of a mixture of calcium carbonate, calcium sulphate, sodium sulphate, and a trace of magnesium sulphate. Hence the salt is about 99½ per cent pure. The potassium ion (K^+) content is 0.177 per cent of the salt, just a little more than one-sixth of 1 per cent. The salt bed is from 550 to 1050 feet in depth, and the artesian water, which is sulphur, is from the 1720-foot level. Flow of well is two gallons per minute."

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[49]Letter to Dr. J. A. Udden.

Rock salt has been reported from many wells in Pecos County; depths and thicknesses of this salt are tabulated under "Well Data."

POTASH

Potash, mainly in the form of polyhalite but with some records of soluble salts, is known from eastern and central Pecos County, in the following wells:

Pinal Dome: Polyhalite thought to be present, 1780–1795 feet.

Noelke (Reilly): Picked samples of red salt at 590 and at 820 feet depth stated to contain 14.3% (KCl). Brine at 2768 and at 2877 stated to show 0.8% (K_2O).

Perry 1 (Transcontinental; 5-Z): Driller's log records potash at 770–775; 775–870, 950–1040, 1080–1150, 1200–1220 feet. Sample examination showed:

Salt, with small amount of polyhalite	845–860
Salt, clay and polyhalite	880
Salt, with considerable polyhalite	900–915
Salt, with a little polyhalite	935
Salt, clay and some polyhalite	975
Approximately one-half salt, one-half polyhalite, pale pink	1000–1005
Salt, and some polyhalite	1055

Menzie-Sherbino 1: "Two brines, one from 1950 and another from 2300 feet, were found to contain some potash. Probably between 0.7 and 1.0 per cent of the total dissolved salts in each of these samples was potash. No samples of salt were collected for tests." (O. C. Wheeler Report, March, 1920.)

Transcontinental-Sherbino 1: "The samples containing more than 1 per cent of potassium are reported in per cent of soluble portion, as follows:

Depth	Soluble Portion	Potassium (K)	Potash (K_2O)
990–1010	72.52%	2.2 %	2.64%
1010–1040	67.22	2.2	2.64
1055–1070	99.14	.16	.19
1070–1080	80.30	4.87	5.86
1080–1105	97.06	.69	.83
1105–1115	*	5.82	6.99
1170–1185	88.54	2.00	2.40
1185–1210	83.69	2.00	2.40
1220–1240	92.10	1.47	1.76
1285–1310	92.20	2.00	2.40
1420–1430	100.00	1.71	2.05
1430–1450	93.90	1.38	1.61

*Cuttings from 1105–1115 feet have K expressed in per cent of total sample. Data by Dr. E. P. Schoch."

White and Baker 1(Gulf): Examination of samples shows the following results:

1140–1170	Considerable polyhalite
1170–1200	Considerable polyhalite
1200–1225	Considerable polyhalite
1225–1260	Considerable polyhalite
1260–1275	Polyhalite present
1305–1325	Polyhalite present
1325–1350	Polyhalite present
1350–1370	Polyhalite present
1370–1375	Considerable polyhalite
1370–1390	Considerable polyhalite
1390–1410	Polyhalite abundant
1410–1430	Considerable polyhalite
1430–1450	Polyhalite more rare
1450–1455	Considerable polyhalite
1454–1470	Anhydrite; practically no polyhalite
1470–1485	Anhydrite; practically no polyhalite
1485–1495	Red salt and anhydrite; practically no polyhalite
1490–1510	A little polyhalite
1510–1525	Mainly pure rock salt; a few fragments of polyhalite
1525–1545	Polyhalite more rare
1535–1545	Polyhalite present
1545–1565	Polyhalite abundant
1565–1580	Considerable polyhalite

The most polyhalite was seen and weighed in the sample at 1390–1410; it was abundant at 1140–1170, and 1225–1260. Percentages are omitted because they would be misleading. All the finer particles were not picked out, a circumstance which would make the percentages too low; on the other hand, solution of salts by the drilling water might make the percentages high. The samples are contaminated by caving, and at some levels all of the polyhalite seen may have come from a higher level. However, a comparison of the samples indicates that there may be beds of more abundant polyhalite at or near the following levels: 1140–1170, 1225–1260, 1390–1410, 1545–1565, and possibly others. The fact that there are interspersed between the rock salt-polyhalite samples other samples of anhydrite or rock salt which are practically free from polyhalite indicates that at certain levels at least there was little caving, and therefore that the occurrence of polyhalite in nearly every sample in this suite

makes it probable that the polyhalite is pretty generally distributed throughout this mass of rock salt. This conclusion is indicated by the prevalent occurrence of rock salt and polyhalite in the same fragment. It is therefore possible that in this well polyhalite occurs in both the segregated and the dispersed condition. Obviously for mining purposes, the segregated condition is more economical. Tests for percentages of soluble salts at the various depths in this well are not available.

Lang[50] reports potash from Pecos County as follows: "Menzie-Transcontinental well, 7.83% of K_2O at 1105–1115 feet" (in 1925); the Perry and the Sherbino wells or fields are given as "lying within the supposed boundary of Permian salt deposition."

SULPHUR

The following facts are in part summarized from a report by J. A. Udden.[51]

(a) Old Shallow Oil Field (Section 19, Block 140, Pecos County): The log of the old Turney well (date 1900; elevation 2578; depth 1200 feet) records "almost pure sulphur" at 200–250 feet, and at 400–525 feet, and "quartz rock with sulphur" at 250–400 and at 540–600 feet. "If the log is correct, we would have fifty feet of almost pure sulphur from the 200-foot to the 250-foot level, and 125 feet of almost pure sulphur from the 400-foot to the 525-foot level. In other words, we would have 175 feet of almost pure sulphur down to the 525-foot level." "A sample of dirt from the dump of this well, taken on my recent visit to the place (September, 1917), contained 87.2% of sulphur." The Dupont Powder Company well No. 2, nearby, recorded "blue limestone and sandstone, with sulphur," 210–220; "quartz rock, and sulphur in small amount, evidently in separate strata," 250–270; "quartz rock, and sulphur in

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[50]Walter B. Lang, Potash Investigations in 1924, U. S. Geol. Surv. Bull. 785-B, 1926.

[51]J. A. Udden, Report on the probability of the existence of sulphur on Survey 623, Socorro E. Co., Pecos County, Texas. Ms., 1917.

slightly increased quantity," 270–280; "quartz rock, porous, with some sulphur," 280–290; "quartz rock, and sulphur in solid strata," 290–300; "blue clay and lime rock, with some sulphur," 300–306; "quartz rock and sulphur," 370–400; "white rock (limestone?) and sulphur," 420–423. A sample of dirt from the dump of this well showed 56.8% of free sulphur. The Dupont Powder Company No. 1 (on 18:140) recorded sulphur and red clay at 270 feet. The log of the Calumet and Arizona Copper Company No. 2 (on 19:140) records no sulphur, but Dr. Udden noted sulphur in a dried slush pit believed to be from this well. Sulphur was noted on the dried slush pit of the Calumet and Arizona Copper Company's well No. 1; "it is said that there was more sulphur found in this boring than in the hole 50 feet west from the Kinsella boring" (i.e., Calumet and Arizona No. 2). From about 205 feet to 576 feet, there was more or less sulphur, some of it in crystals. The log of Dupont Powder Company No. 2 (on 19:140) records sulphur at various depths between 210 and 448 feet. The log of Grant No. 8 records sulphur at 200–202 feet; Grant No. 11 records sulphur at 135–138 feet.

(b) Histed Well: This well (on Survey 210) flows a large quantity of salt water with odor of hydrogen sulphide, but no sulphur was recorded. The same is true of several nearby wells.

(c) Artesian Wells on Survey 623, Socorro E. Co.: This survey is about 8 miles north of Fort Stockton, just north of the first turn of the Grandfalls road. About 1902, two wells were drilled close together and south of a water seep (elevation 2809 feet). There was a flow of water from a yellow sandstone at 192 feet depth. The presence of sulphur was claimed; sample from old slush pit upon analysis, showed no free sulphur; the water which flows from the wells has a perceptible odor of hydrogen sulphide, and in 1910 had a temperature of 68° F.

Dr. Udden considers that this subsurface accumulation of sulphur on Section 19, Block 140, is probably strictly local, and is the result of oxidation of sulphur gases rising from considerable depths through an ill-defined, somewhat

pervious passage extending downwards at that place. This type of accumulation is compared with that found in the Toyah region. Drilling has so far failed to reveal whether other places in Pecos County, marked by escaping hydrogen sulphide gas, are sites of underground sulphur accumulation.

(d) Bennett 1: A sample from 855 feet in Bennett 1 (Grant 12) well on Section 592 consists of "layers of gray limestone alternating with layers of yellow sulphur." The log records "native sulphur, 550–850."

LIMESTONE

Building stone has been taken from Quarry Hill, three miles west of Fort Stockton since the first settlement of the town. An old quarry supplied the stone which was used in the construction of the army post buildings about 1858. Most of the stone houses in the town are built of stone from the newer quarry in the same hill. This is a grayish, medium-bedded limestone, most layers hard and compact without cavities but some layers slightly shelly, and somewhat resembles the Edwards limestone of South-Central Texas. It may be seen in the Stockton Hotel and the old Orient Station. A small amount of building stone is reported to have been taken from the hard ledges of the Kiamichi, about a mile south of Fort Stockton.

There are no valuable deposits of clay known in the immediate vicinity of the town. Alluvial clay is generally used for adobe. No commercial deposits of gravel have been opened up; the gravel and sand used here are shipped in from localities farther northeast on the Orient Railway. As has been mentioned, Pleistocene deposits are thin, or perhaps generally missing, near Fort Stockton.

WELL DATA

Description of Samples from W K. Maul's Batchler No. 1, Located on Section 89, Block O. W. G. C. & S. F. Ry., 10 Miles West of Fort Stockton, Texas. Submitted by M. K. Maul, Fort Stockton, Texas, July 22, 1924

Depth in Ft.

Sample consists of light gray, nearly white, siliceous rock, which has the appearance of limestone, in which the lime has been replaced by silica. There is an abundance of pyrite. The rock also shows the presence of sand grains in the original rock. This sand is mostly below one-eighth of a millimeter in diameter, with a few coarse grains that measure one-half of a millimeter. Comanchean. J. A. Udden and F. C. Owens 222

Sample consists of red calcareous clay in which small pebbles occur in lumps of purplish red clay. In the washed materials numerous grains of subangular to rounded clear quartz grains and a few pink grains of quartz were observed. Much pyrite present. Calcite noted. Fragment of a sponge spicule noted. Grains in the sample give the test for phosphate 405

Sample consists of brown calcareous clay with lumps of purplish brown clay. In the washed material sub-angular to rounded clear quartz grains were seen to be present in abundance. Pyrite observed in large quantities. In the sample was found a single spherical grain evidently calcareous ornamented with shallow grooves, some of which radiate irregularly from a point on the surface. This sphere measures one millimeter in diameter. It is not perfectly spherical, some of the grooves run obliquely suggesting a resemblance to a chara seed. The material of which it is made has an amber color and appears to be quite hard 412

Sample consists of cuttings of light gray indurated limestone of fine texture and dark gray limestone of a coarser texture. Compact gray dolomite which was difficult to dissolve, was noted in the washed material. Soft dark shale present, also a few grains of clear quartz. Indistinct organic fragments noted in thin section. Limestone was seen to be fine grained in thin section. Probably Cretaceous. E. H. Sellards and O. M. Richey 420

Sample consists of cuttings of light gray, calcareous clay. In the washed material quartz sand was noted. Some of the grains were highly polished and a few were well

Depth in Ft.

rounded. Dark gray and pink chert grains, pyrite and fragments of light gray limestone are present. Several of the bodies resembling chara fruits and described in the sample from 412 feet are present. An ornate ostracod and echinoid spines and tissues are present..... 444

Sample consists of several fragments of gray limestone containing some pyrite. One fragment of light gray almost white, fine grained sandstone noted. In thin section the limestone was seen to be fine grained and to contain numerous organic fragments, part of which have been filled with calcite. Much pyrite and a grain of glauconite present..... 444

Sample consists of cuttings of light gray calcareous clay with a few fragments of gray and white limestone. In the washed material some quartz sand noted. Some of the larger grains are fairly well rounded. Pyrite present. Several of the organic bodies described in the sample from 412 feet were noted in this sample. An echinoid spine present. Probably from the Cretaceous. R. T. Short. 446

Description of a Sample from Belding No. 2 Well, Located about 12 Miles Southwest of Fort Stockton. Keystone Churn Drill. Described by J. A. Udden

Pink or pale red marl of fine texture. It contains a small amount of sand. No foraminifera noted. In the sand two spine-like bodies were noted, somewhat irregular in shape. Material of this kind occurs in the base of the Comanchean near Tessey postoffice, some 10 miles south of Belding, and is there associated with layers of limestone, sand and gravel..... 315

Gray sand mostly consisting of grains measuring from one-eighth to one-fourth mm. in diameter. A few minute fragments of lignite, considerable pyrite, and some grains of concretionary white limestone noted. Two oval calcareous fossils noted, having a spiral groove. One of these was broken and was seen to be hollow, consisting of a wall built by a spiral thread. Evidently a chara seed. 315

Log of Bennett No. 2, Trans-Pecos Oil Company, 1528 Feet from East Line, 2024 Feet from North Line, Section 592, G. C. & S. F.; T. D. 1405+ Feet. Elevation 2562 Feet

Formation:	Depth in Ft. From	To	Thickness
Log missing	.....	707	707
Gray lime	707	801	31
Gray lime and blue shale	769	800	31
Gray lime and white sulphur	800	810	10
Sand, some sul and sul water	810	825	15
Gray lime	825	839–	14
Blue and brown lime	839	847	8
Brown lime	847	850	3
Gray lime	850	863	13
White lime	863	870	7
Lime	870	881–	11
White and brown lime	881	893	12
White lime	893	940	47
White and brown lime	940	972	32
Brown sand	972	982	10
Gray lime	982	1000	18
Sandy gray lime	1000	1006	6
Gray lime and gyp	1006	1042	36
Black shale	1042	1057	15
Hard sand	1057	1059	2
Gray sandy lime	1059	1062	3
Gray lime and black shale, gas	1062	1064	2
Black shale and lime	1064	1075	11
Hard gray lime	1075	1080	5
Hard gray lime and blue shale	1080	1087	5
Blue lime and shale	1087	1090	3
Hard white lime	1090	1094	4
Lime, some oil at 1098 feet	1094	1100	6
Lime	1100	1132	32

Description of Samples from the Bennett No. 2, Quinby Oil Co., Located in the Center of the N. W. One-fourth of Section 592, Block 105, G. C. & S. F. Survey, 15 Miles North and 6 Miles East of Fort Stockton, Pecos County, Texas. Submitted by H. L. Baldwin, Geologist, Quinby Oil Co., Fort Stockton, Texas. Described by O. M. R. T.D. (May 6, 1927), 1457 Ft.; El. 2562 Ft.

Depth in Ft.

Sample consists of cuttings of dark reddish-brown [shale?]
A very few fragments of light gray limestone and reddish-brown slightly calcareous sandstones were noted in

	Depth in Ft.
the washed material. Subangular to rounded grains of clear quartz present. A little pyrite noted	302–306
Sample consists of cuttings of drab reddish-brown and light gray, slightly calcareous medium-grained sandstone, and and a few fragments of reddish-brown noncalcareous shale. Clear quartz grains in the washed material were seen to be subangular. Some pyrite present	306–314
Like preceding sample from 306–314 feet	314–332
Sample consists of cuttings of drab reddish-brown, slightly calcareous, fine-grained sandstone, reddish-brown noncalcareous shale and some light gray, slightly calcareous, medium-grained sandstone. Clear quartz grains in the washed material were seen to be subangular to rounded	322–333
Sample consists of cuttings of dark reddish-brown fine-grained, slightly calcareous sandstone and reddish-brown noncalcareous shale. Coarse-grained, slightly calcareous gray sandstone was noted in the washed material. The clear quartz grains were seen to be subangular to rounded in shape	333–340
Like sample from 333–340 feet. Pyrite present	340–350
Sample consists of cuttings of drab reddish-brown noncalcareous shale and white dolomitic limestone. Fine-grained reddish-brown sandstone, coarse-grained light gray sandstone, and a little pyrite were found in the washed material	350–360
Sample consists of cuttings of dark reddish-brown noncalcareous shale and pinkish-gray calcareous clay. Gypsum, light gray lime, and subangular to rounded grains of clear quartz were observed in the washed material	360–368
Sample consists of cuttings of pinkish-gray calcareous clay. Light gray to white limestone, reddish brown noncalcareous shale, light gray sandstone, and gypsum were noted in varying amounts in the washed material	368–369
Sample consists of cuttings of medium gray, compact, dolomitic limestone. A few fragments of coarse-grained gray sandstone and medium-grained brown sandstone were seen in the washed material	369–374
Sample consists of cuttings of light gray, compact, dolomitic limestone. The washed material was found to contain fragments of reddish-brown sandstone, pyrite and subangular to rounded grains of clear quartz	374–385
Sample consists of cuttings of medium and dark gray dolomitic limestone. Pyrite and a few subangular to rounded quartz grains were noted in the washed material	385–390

	Depth in Ft.
Sample consists of cuttings of medium gray calcareous sandstone of medium grain, light gray to white dolomitic limestone, and a very little pyrite	390–400
Sample consists of cuttings of gray, medium-grained, calcareous sandstone. Two or three fragments of white limestone noted	400–407
Sample consists of cuttings of medium and fine-grained calcareous sandstone	407–412
Sample consists of cuttings of gray, sandy, calcareous shale	412–418
Sample consists of cuttings of medium gray crystalline limestone, some clear quartz, and a little pyrite	418–428
Sample consists of cuttings of medium gray limestone. A little calcite and pyrite present. Oolitic spherules measuring three-fourths mm. noted	428–440
Like sample from 428–440 feet. No pyrite noted	440–455
Sample consists of cuttings of medium gray limestone, coarse-grained gray calcareous sandstone, and subangular grains of clear quartz. Calcite, pyrite and oolitic spherules noted	455–462
Like sample from 455–462 feet	462–470
Like sample from 455–462 feet	470–480
Sample consists of cuttings of reddish-brown noncalcareous shale, gypsum, and a little gray limestone. A little pyrite present	480–490
Sample consists of cuttings of gypsum. A very little pyrite noted	490–500
Sample consists of a piece of drab reddish-brown calcareous shale. Gypsum, subangular grains of clear quartz, and some brownish-gray limestone were noted in the washed material.	500–506
Sample consists of cuttings of gypsum. A little anhydrite and some pyrite present in the washed material	506–512
Sample consists of cuttings of medium gray limestone, anhydrite and gypsum. A little pyrite present	512–515
Sample consists of cuttings of medium gray limestone, gypsum and anhydrite	515–520
Sample consists of cuttings of gypsum and anhydrite. A few fragments of medium gray limestone noted	520–530
Sample consists of cuttings of gypsum anhydrite and a little reddish-brown noncalcareous shale, and pyrite	530–537
Like sample from 530–537 feet	537–540
Sample consists of cuttings of medium gray crystalline limestone, gypsum, anhydrite, a little reddish-brown noncalcareous shale, and some pyrite	540–545

Sample consists of cuttings of light gray crystalline limestone, anhydrite and gypsum	545–552
Like sample from 545–552 feet	552–560
Like sample from 545–552 feet	560–570
Sample consists of cuttings of medium gray crystalline limestone and anhydrite	570–575
Like sample from 575–85 feet. A few fragments of reddish-brown noncalcareous shale present	585–595
Sample consists of cuttings of anhydrite and gypsum. A few fragments of brownish-gray dolomitic limestone noted	575–585
Sample consists of cuttings of anhydrite and gypsum. Pyrite, clear quartz crystals, and a few fragments of coarse-grained gray sandstone were noted	585–595
Sample consists of cuttings of anhydrite and gypsum	595–598
Like sample from 595–598 feet. A little pyrite noted	603–608
Like sample from 595–598 feet	608–614
Like sample from 595–598 feet	614–622
Like sample from 595–598 feet	622–626
Sample consists of cuttings of anhydrite and some gypsum	626–630
Like sample from 626–630 feet	630–632
Like sample from 626–630 feet	632–636
Sample consists of cuttings of anhydrite, some gypsum, and a little pyrite	636–641
Like sample from 636–641 feet	641–645
Like sample from 636–641 feet	645–648
Sample consists of cuttings of anhydrite and some gypsum	648–653
Like sample from 648–653 feet	653–660
Like sample from 648–653 feet	660–668
Like sample from 648–653 feet. A little pyrite present	675–679
Sample consists of cuttings of gypsum and anhydrite	683–690
Like sample from 683–690 feet	690–695
Like sample from 683–690 feet	695–700
Like sample from 685–690 feet	700–704
Sample consists of cuttings of anhydrite and gypsum. A fragment of gray, slightly calcareous sandstone was noted. Pyrite and several almost perfect clear quartz crystals present	704–711
Sample consists of cuttings of anhydrite and gypsum	711–715
Like sample from 711–715 feet	715–720
Sample consists of cuttings of anhydriteand gypsum. Pyrite and several almost perfect crystals of clear quartz were noted	720–725
Like sample from 720–725 feet	725–735
Sample consists of cuttings of anhydrite, gypsum and medium gray dolomitic limestone. Pyrite and several almost perfect clear crystals present	735–740

	Depth in Ft.
Like sample from 735–740 feet. No pyrite noted	740–745
Sample consists of cuttings of brownish-gray dolomitic limestone, anhydrite, and gypsum. Several almost perfect clear quartz crystals were observed	745–749
Like sample from 745–749 feet	750–755
Like sample from 745–749 feet. A little pyrite noted	755–762
Like sample from 745–749 feet. Pyrite present	762–770
Sample consists of cuttings of anhydrite and gypsum. Almost perfect crystals of clear quartz noted	770–775
Like sample from 770–775 feet. A little pyrite noted	775–780
Like sample from 770–775 feet. Pyrite present	780–781
Like sample from 770–775 feet	781–792
Sample consists of cuttings of anhydrite and a little gypsum	792–797
Sample consists of cuttings of anhydrite and gypsum. Pyrite and several almost perfect clear quartz crystals noted	797–802
Like sample from 797–802 feet	802–806
Like sample from 797–802 feet	806–808
Sample cossists of cuttings of anhydrite and gypsum. Pyrite, a few fragments of gray sandstone, and several almost perfect crystals of clear quartz were noted	818–825
Like sample from 818–823 feet	825–833
Sample consists of cuttings of anhydrite and gypsum. Several almost perfect clear quartz crystals present	840–843
Like sample from 840–843 feet. Pyrite present	843–849
Sample consists of cuttings of anhydrite and gypsum. Pyrite, fragments of gray sandstone, and several almost perfect crystals of clear quartz present	894–854
Like sample from 849–854 feet	854–861
Sample consists of cuttings of anhydrite, gypsum and a few fragments of noncalcareous reddish-brown sandstone. Pyrite and almost perfect clear quartz crystals were noted	867–868
Sample consists of cuttings of anhydrite and some gypsum. Almost perfect crystal of clear quartz, and a few fragments of gray coarse-grained sandstone were noted	873–885
Sample consists of cuttings of anhydrite and some gypsum. Clear quartz crystals noted	885–895
Like sample from 885–895 feet. Pyrite present	895–800
Sample consists of cuttings of anhydrite and some gypsum. Clear quartz crystals noted	900–910
Sample consists of cuttings of anhydrite and gypsum	910–915
Like sample from 910–915 feet	915–920
Sample consists of cuttings of brownish-gray dolomitic limestone, with some anhydrite and gypsum. A little pyrite present	930–940

	Depth in Ft.
Like sample from 930–940 feet. No pyrite	940–950
Like sample from 930–940 feet. No pyrite present	950–962
Sample consists of cuttings of brownish-gray dolomitic limestone, gypsum, and anhydrite. Almost perfect scalenohedrons of clear quartz were noted	962–970
Sample consists of cuttings of brownish-gray dolomitic limestone and gypsum. Clear quartz crystals, both scalenohedrons and prism type, noted	972–980
Sample consists of cuttings of brownish-gray dolomitic limestone, anhydrite, and gypsum. Clear quartz crystals present	980–990
Sample consists of cuttings of anhydrite, gypsum, and some brownish-gray dolomitic limestone	990–1000
Sample consists of cuttings of anhydrite and some gypsum. A few fragments of brownish-gray dolomitic limestone and several crystals of clear quartz present	1000–1008
Like sample from 1000–1008 feet	1008–1018
Sample consists of cuttings of anhydrite with some dolomitic limestone and gypsum	1018–1025
Sample consists of cuttings of anhydrite and a few fragments of dolomitic limestone	1025–1030
Like sample from 1025–1030 feet	1030–1040
Sample consists of cuttings of anhydrite and dolomitic limestone	1040–1045
Sample consists of cuttings of anhydrite with some gypsum and dolomitic limestone	1045–1050
Sample consists of cuttings of brownish-gray dolomitic limestone and anhydrite	1050–1060
Like sample from 1050–1060 feet	1060–1070
Like sample from 1050–1060 feet	1070–1078
Sample consists of cuttings of brownish-gray dolomitic limestone and anhydrite. Clear quartz crystals present	1080–1090
Like sample from 1080–1090 feet	1090–1095
Sample consists of cuttings of brown dolomitic limestone. Some anhydrite and a very little gypsum noted	1095–1100
Sample consists of cuttings of brown dolomitic limestone and some anhydrite	1100–1105
Sample consists of cuttings of brown dolomitic limestone, some anhydrite, and a very little gypsum	1105–1110
Like sample from 1105–1111 feet	1110–1123
Sample consists of cuttings of brown dolomitic limestone and some anhydrite	1123–1132
Like sample from 1123–1132 feet	1131–1133
Sample consists of very fine cuttings of brown dolomitic limestone. Some anhydrite and clear quartz present	1133–1134

	Depth in Ft.
Like sample from 1133–1134 feet	1134–1145
Sample consists of cuttings of brown dolomitic limestone and anhydrite. A very little gypsum present	1143–1153
Sample consists of cutting of brown dolomitic limestone, anhydrite, and gypsum	1155–1164
Sample consists of cuttings of brown dolomitic limestone, gypsum, and anhydrite. A little pyrite present	1164–1170
Sample consists of cuttings of dark gray medium-grained noncalcareous sandstone. Well worn, almost rounded quartz grains measuring three-fourths mm. in diameter were noted in the washed material. A few fragments of anhydrite and brownish-gray dolomitic limestone were noted	1170–1186
Like sample from 1170–1186 feet. Some gypsum noted	1186–1190
Like sample from 1170–1186 feet. A little gypsum present	1190–1192
Sample consists of cuttings of dark brownish-gray medium-grained sandstone and dolomitic limestone. Worn, almost round, quartz grains three-fourths mm. in diameter, and a very little pyrite noted	1192–1196
Like sample from 1192–1196 feet	1196–1200
Like sample from 1192–1196 feet	1200–1204
Like sample from 1192–1196 feet	1204–1208
Like sample from 1192–1196 feet	1208–1212
Like sample from 1192–1196 feet	1212–1216
Sample consists of cuttings of brownish-gray dolomitic limestone and a few fragments of medium-grained noncalcareous sandstone	1216–1218
Sample consists of cuttings of brownish-gray dolomitic limestone and medium-grained noncalcareous sandstone. Worn almost round, quartz grains three-fourths mm. in diameter and some pyrite present	1220–1222
Like sample from 1220–1222 feet. No pyrite	1222–1224
Sample consists of cuttings of brownish-gray medium-grained sandstone and a few fragments of dolomitic limestone. Rounded, worn, quartz grains and a little pyrite noted	1224–1226
Like sample from 1224–1226 feet	1226–1228
Sample consists of cuttings of brownish-gray dolomitic limestone and medium-grained noncalcareous sandstone. A little pyrite noted	1228–1230
Sample consists of cuttings of brownish-gray dolomitic limestone, light gray sandstone, gypsum, and a little pyrite. Several rounded well worn grains of clear quartz noted	1230–1234
Sample consists of cuttings of brownish-gray dolomitic limestone, gypsum, clear quartz, and a little pyrite	1234–1235

	Depth in Ft.
Sample consists of very fine cuttings of light gray limestone, gypsum, and clear quartz	1245–1248
Sample consists of cuttings of medium gray and brownish-gray limestone	1248–1250
Sample consists of fine cuttings of clear quartz, gray limestone, and gypsum	1254–1260
Sample consists of cuttings of gray limestone, brownish-gray sandstone, gypsum, and clear quartz. Several rounded, worn, grains of clear quartz present	1260–1266
Sample consists of cuttings of small angular grains of clear quartz and some gray sandstone. A few fragments of gray limestone, gypsum, and a little pyrite noted	1266–1270
Sample consists of cuttings of gray limestone and some gray and brownish-gray sandstone. Several rounded, worn, clear quartz grains present	1270–1276
Sample consists of cuttings of light gray limestone. A very little pyrite and a few rounded,worn, grains of clear quartz noted	1276–1282
Sample consists of cuttings of light gray limestone, brownish-gray sandstone, and clear quartz	1282–1298
Sample consists of cuttings of gray limestone, bluish-gray slightly calcareous shale, and some clear quartz	1298–1302
Sample consists of cuttings of gray limestone and a few fragments of bluish-gray noncalcareous shale	1305–1306
Sample consists of cuttings of light gray limestone	1305–1309
Sample consists of cuttings of medium gray limestone and some gray sandstone	1308–1311
Sample consists of cuttings of medium gray limestone. A very little clear quartz and pyrite present	1314–1316
Sample consists of cuttings of gray limestone and some clear quartz	1316–1317

Log and Description of Samples from the United States and Mexican Trust Company's Test, Buena Vista. Location: Survey 29, Block 2, H. & T. C. Ry. Lands at the Buena Vista Postoffice, Pecos County, Texas.

	Depth in Feet	
	From	To
Adobe soil		25
Sand and gravel, with brackish water near bottom	25	220
Red rock mostly soft and shaly, with some very hard black pebbles all the way through	220	450
Water sand	450	451
Red rock, like that from 220–450 feet	451	531
Red sandstone	555	588

	Depth in Feet	
	From	To
Red clay	588	600
Red clay and sandstone, in which were two layers of white gypsum or limestone	600	620
Red sandstone	at	620
Hard finely granular white gypsum with some pink coarsely crystalline gypsum		700
Pieces of white hard, finely crystalline gypsum		900
Rock salt reported by the driller		962
Rock salt reported by the driller		975
Chocolate-colored marly clay, containing some fine quartz sand, considerable crystalline gypsum		1000
Chocolate-colored marly clay, containing some fine quartz sand, considerable crystalline gypsum, and a few intensely green grains of some silicate		1014
Chocolate-colored marly shale, like the preceding, with more crystalline gypsum and with some microscopic crystals of quartz		1029
Like the sample from 1014 feet, with some white grains of calcareous material		1020
Chocolate-colored marly clay of fine texture with some fragments of red sandy rock and some fragments of soft greenish-gray shale. Selenite occurs in large fragments. There are small nodules of white concretionary carbonate of lime		1033
Red shaly clay, with much gypsum and also some greenish gray shale, which adheres to the gypsum. Some minute white nodules of carbonate of lime		1038
Red and greenish gray shale with gypsum and fragments of calcareous material. Some bright green grains noted		1047
Red marl containing a considerable quantity of gypsum, some sand and some calcareous material. The carbonate of lime is partly in the form of white grains, partly in greenish gray grains		1066
Red marly clay, with much gypsum, some sand, and some calcareous material		1067
Red marl and bluish gray shale, with much gypsum and some sand. Some clear calcite was noted		1073
Red marl, gypsum, fine quartz sand, and occasional green grains of some silicate		1084
Like the preceding		1090
Red and gray marly shale, containing some sand and gypsum		1133

	Depth in Feet From	To
Red shale and greenish gray shale containing gypsum and a small amount of very fine sand		1152
Gray shale, sand, gypsum and very rare fragments of limestone		1205
Gray shale and fragments of a straw-colored rock containing imbedded fragments which seem to be organic. Some gypsum noted		1300
Like the preceding		1324
Red and gray shale, some gypsum and much cream-colored limestone		1377
Gypsum and shale, with some sand and yellow limestone		1385
Gray sand, shale and gypsum with a few fragments of carbonate of lime		1390
Fine silt, with minute spherical yellow calcareous concretions and with fragments of white limestone		1397
Fine quartz sand and silty shale, with fragments of yellow limestone and of gypsum. Some pink and some green grains noted		1414

NOTE.—Different parts of this record were obtained in different ways, and from different parties, as follows:

From the surface down to 555 feet, the log is a memory record obtained from the first driller, in September, 1910.

From 555 feet down to 620 feet, the log is also a memory record furnished by Mr. Hall Harrison, in December, 1910.

From 620 feet to 962 feet, nothing is known about the materials penetrated, except what can be inferred from two samples of gypsum, one of which was taken from the depth of 700 feet and the other from the depth of 900 feet. Evidently there were beds of gypsum at these depths.

Rock salt was reported by the driller at the depth of 962–972 feet. This is corroborated by the fact that the water coming out of the bucket from the depth of 1035 was found by analysis to contain 26.3 per cent of salt, and that coming from the depth of 1040 feet contained 24.9 per cent.

The last 50 feet show some limestone. But from the small size of the samples and from the conditions of the drilling (it is assumed that the well was not cased for some distance in the lower part) it is not possible to say whether the limestone fragments have come from a solid limestone formation or from thin shells of limestone imbedded in shales. My opinion is that it is not from a solid ledge of limestone. J. A. Udden.

Description of Samples from Devlin 1 Drilled by the Pinal Dome Corporation, Located Section 208, James Burleson Survey, 7 Miles Northeast of Fort Stockton. Submitted by Mr. H. L. Baldwin, Box 14, Fort Stockton, Texas. Described by E. M. Hawtof. April 25, 1927

	Depth in Ft.
Bits of white limestone in abundance, also large amount of gypsum; few fragments of grayish shale present	23
Fragments of cream-colored marl; a few irregular-shaped grains of dull quartz were noted	25
Grayish limestone and some bits of brownish-gray limestone; with fragments of gypsum	30
A large amount of gypsum; a considerable amount of grayish limestone, and many bits of greenish shale	36
Cream-colored highly calcareous marl, and also bits of hard cream-colored limestone	70–75
Yellowish medium hard limestone, with small blackish irregular areas composed of magnetite. Same at 80	79
Yellowish-gray medium hard limestone, and some yellowish limestone. Same at 92 and 93	88
Same as sample at 93 feet, some fragments were almost in the shape of pebbles, but of dark yellowish-brown limestone	96
Sample was very small, but appeared to be composed of same material as sample from 96 feet	100
Yellowish hard limestone, practically the same as sample 100 feet	105
Very small fragments of yellowish and light gray hard limestone	107
Light yellowish sandy marl. The washed material consisted of an abundance of poorly sorted dull quartz grains, subangular to angular, a few fairly well rounded grains were present; all the grains were observed to be slightly etched. Gypsum was noted. Fragments of yellowish hard limestone were present in a fair amount	117
Light yellowish sands. The washed material consisted of dull quartz grains, fairly well sorted, .22 and .30 mm. in size. The gains were chiefly subangular to angular in shape, all considerably etched and worn. (Trinity)	121
Reddish calcareous sandy clay, in which a considerable amount of gypsum flakes were noted, also the quartz grains were rose-colored. A small irregular inclusion of grayish calcareous material was noted	141
Same as sample at 121 feet; except in this sample the grains were better sorted, being the same size as those in 121 feet; fairly well rounded grains were noted in this sample	145
The sand grains were of dull quartz	155

Depth in Ft.

Dark grayish calcareous clay, of medium hardness. A small inclusion of highly calcareous material was noted.... 170

Same as sample at 170 feet, except the color of this one is a lighter gray.... 180

Same as sample at 180 feet.... 185

Grayish calcareous sandy clay, having large inclusions of yellowish calcareous material. The sand grains were quite small.... 188

Same as sample at 188 feet.... 193

Grayish calcareous sand, and fragments of gray highly calcareous clay. The washed faterial was composed of poorly sorted dull quartz grains, from very fine to .32 mm. in size, which were angular to subangular in shape. The sand grains were cemented together by grains of white calcareous material. An abundance of pyrite was noted. The quartz grains were etched and worn.... 197

Same at 200, 205, and 210.

Greenish-gray non-calcareous clay, also pinkish calcareous clay. (Duplicate sample).... 210

Practically same as sample at 200 feet.... 215

Grayish highly calcareous sands. The washed material was composed of an abundance of poorly sorted dull quartz grains, ranging from very fine to about .32 mm. in size. The grains were well worn and etched, being chiefly angular to subangular in shape. Pyrite was noted. Same at 230, 255 and 265.... 225

Sample consists of red calcareous sands, and red calcareous sandy shale. The washed material consisted of a large amount of poorly sorted dull and rose-tinted quartz grains, being in size from very fine to about .45 mm. The grains were noted to be angular or subangular in shape, and they were observed to be fairly well etched and worn. Pyrite was fairly abundant. Lignitic material and a small amount of gypsum was noted.... 285

Same as sample at 285 feet.... 287

Red calcareous sandstone. The washed material consisted of poorly sorted rose and dull quartz grains, which ranged between very fine to about .32 mm. in size, being angular to subangular in shape, and it was noted that the grains were considerably etched and worn. Pyrite was noted fairly abundant. Quite a number of fairly well rounded quartz grains were present.... 297

Gray calcareous sand. Few fragments of grayish quartzite were noted. The washed material consisted of poorly sorted dull quartz, being angular to subangular in shape,

Depth in Ft.

and noted to be fairly well etched and worn. Pyrite was abundant 334

Grayish calcareous sandstone, fragments of greenish-gray calcareous shale was noted. Pyrite was abundant. The sand grains were of dull quartz, which were noted to be poorly sorted, and ranging in size from very fine to .32 mm. The grains were from angular to subangular in shape 335

Red calcareous very sandy clay. The washed material consisted chiefly of poorly sorted rose quartz, ranging in size from very fine to .32 mm., as to shape the grains were from angular to subangular, and appeared fairly etched and worn 355

Same as 355 feet 364

Sample consists of reddish and grayish calcareous sand. The washed material consisted chiefly of dull and rose quartz grains between .32 and .50 mm. in size (coarse), being chiefly angular to subangular in shape. The grains were noted to be only fairly well etched and worn. Magnetite present 371

Red sandy calcareous clay 393

Brownish calcareous sand. The sand consisted of rose and dull quartz grains, and being medium in size, angular to subangular in shape. (Very small sample) 403

Pinkish-brown calcareous, slightly sandy clay 520

Same as sample at 403 feet. (Very small sample) 505

Same at 525, 530, 595, and 645.

A pinkish-brown soft, very porous calcareous sandy clay. The sand was fairly sorted and fine rose quartz 658

Same as 658 feet 665

Same as sample at 658 feet 680

Pinkish calcareous sand. The sand consisted chiefly of clear quartz grains, very fine in size, and angular to subangular in shape 710

A pinkish calcareous, slightly sandy clay, in which was noted irregular inclusions of greenish-gray clay of the same composition. The sand grains were fairly sorted being chiefly very fine in size. Gypsum flakes were noted 715

Sample consists of pinkish, calcareous sandy clay. The sand was composed of fine rose quartz grains. A considerable amount of gypsum flakes were noted. Same at 730, 735, 745, and 755 720

Red slightly calcareous sandy clay, in which was noted small rounded inclusions of grayish clay of the same composition as the main mass of red rock. The sand was

	Depth in Ft.
composed of red and slightly tinted quartz grains of irregular size. Magnetite was present	760
Same as sample from 760 feet	765
Pinkish-brown calcareous, very porous, sandy clay. Fine rose and dull quartz grains and small amount of magnetite were noted	770
Red calcareous, fairly hard, sandy clay in which small inclusions of the same material was noted. The sand was fine rose-tinted quartz grains. Very minute bits of magnetite were abundant	775
Same as sample from 775 feet	780
Sample consists of pinkish, very porous, slightly clacareous and sandy clay. Same at 786, 790, 795, 800, 805, and 815	785
Pinkish-brown fine-textured, calcareous, sandy clay. The sand being very fine-grained tinted quartz. Magnetite and gypsum were present	820
Same as sample from 820 feet	825
A pinkish-brown medium-textured, calcareous, sandy shale. The shale might be termed "fluffy," the sand was composed chiefly of medium to small rose-tinted quartz grains. Gypsum flakes and bits of magnetite noted	838
Same as sample from 838 feet	840
Same as sample from 838 feet	845
Pinkish-brown, slightly calcareous, sandy clay, in which small seams of kaolin were deposited. The sand was composed of fine rose-tinted quartz grains. Same at 855, 860, 865, 870, 875, 880, 890, 895, 900, and 910	850
Pinkish, slightly calcareous and sandy, medium-grained clay, in which minute irregular seams of the same material were noted. The sand was very fine	915
Same as sample from 915 feet	920
Same as sample from 850 feet	925
Same as sample from 850 feet	930
Pink, slightly sandy and calcareous clay, which had large irregular areas of the same material except being gray in color	935
Pink, slightly calcareous and sandy clay, in which many seams of kaolin were noted	940
Same as sample from 940 feet, except lacks the abundance of kaolin. Same at 955, 958, 960, 970, 975, and 980	945
Pink, slightly calcareous and sandy clay, in which was noted seams of grayish, slightly calcareous material	985
Pinkish calcareous, fine-textured, slightly sandy clay, Same at 1000, 1005, 1010, and 1020	990
Same as sample from 940 feet	1025

	Depth in Ft.
Same as sample from 850 feet	1030
Same as sample from 850 feet	1035
Pinkish, slightly calcareous, soft, fine-textured clay. The rock contained very little fine-grained sand. Same at 1045, 1050, 1055, 1060, 1065, 1075, and 1080	1040
Practically the same as sample from 1040 feet, with the addition of red, slightly calcareous, sandy, hard shale	1085
Pinkish-brown, soft, sandy, calcareous clay. The washed material consisted of fine slightly yellowish-tinted quartz grains, subangular to angular, with a number of fairly well rounded grains. Gypsum present. Same at 1101, 1105, 1115, and 1120	1095
Very coarse sand. The washed material was composed chiefly of a large quantity of mostly dull and a fair amount of dark-grayish quartz grains which were chiefly rounded in shape, and above .45 mm. in size. The grains were well sorted. Gypsum noted	1121
Pinkish-brown calcareous sandy clay, which was noted to have a fairly fine texture, and the rock was also found to be soft in character	1125
Practically same as sample from 1125 feet, except this sample has small areas of grayish-white clay which are practically the same in composition except lack the red color	1130
Same as sample from 1130 feet. Bits of white non-calcareous clay were present	1135
Same as sample from 1135 feet	1140
Pinkish-gray calcareous sandy clay, in which poorly sorted dull quartz grains were fairly abundant. The grains had various shapes. A considerable amount of gypsum was noted. Fragments of grayish shale and also white calcareous clay was present	1145
Red, slightly sandy and calcareous clay. (Very small sample.)	1155
Dark pinkish-red, medium-textured, slightly calcareous, fairly sandy clay, in which small inclusions of gypsum noted, also small areas of grayish material. The composition of this material was the same as the pinkish red clay, except lacked the reddish color	1160
Same as sample from 1160 feet	1165
Same as sample from 1160 feet	1170
Pink, calcareous, slightly sandy, porous, fairly soft, clay. The sand grains were somewhat fine	1175
Same as sample from 1175 feet, except numerous very small inclusions of white non-calcareous material. (Possibly kaolin.)	1180

	Depth in Ft.
Same as sample from 1180 feet	1185
Other sample from same depth was composed of many large bits of grayish, highly calcareous material	1185
Same as samples from 1185 feet. The rock is soft and highly calcareous	1190
Red, calcareous, slightly sandy clay, in which small grayish areas of the sand were noted	1195
Pinkish-white, highly calcareous, sandy, finely porous, soft, clay. Few very fine dull and clear quartz grains were noted less than .10 mm., in size. Pyrite and gypsum were present in the washed material	1205
Red, very slightly calcareous, sandy, very porous shale, in which gypsum was noted. The sand consists of fine rose-tinted quartz grains	1210
Light yellowish-gray, hard limestone, which looks like anhydrite. Magnetite was abundant. Gypsum and pyrite were noted	1215
Same as sample from 1215 feet	1220
Same as sample from 1215 feet	1225
A grayish-yellow medium granular-textured, slightly hard limestone, in which was noted a considerable amount of magnetite and gypsum. Numerous fragments of the limestone were stained by the Fe. Same from 1230, 1235, 1239, 1242, 1243, 1245, 1246, 1247, and 1250	1229
Grayish, medium hard, medium somewhat granular limestone. Some of the rock was noted to have many very fine pores. Gypsum and magnetite present. Same at 1256, 1258, 1260, and 1261	1254
Grayish medium hard limestone. An abundance of pyrite was noted. Gypsum was fairly abundant	1263
Same as sample from 1263 feet	1265
Sample consists of various shades of gray and yellow limestone. An abundance of pyrite was noted, especially in the dark gray limestone. A considerable amount of gypsum was present	1266
A grayish calcareous clay, in which was noted fragments of yellowish limestone. An abundance of gypsum was present, also a large amount of pyrite being noted	1269
Same as sample from 1269 feet	1272
Fragments of cream-colored and white limestone, very minute flakes of gypsum were noted to be cemented together in a mass by white calcareous material. Many large bits of gypsum were observed. A medium quantity of very fine-grained sand was noted (less than .15 mm.	

Depth in Ft.

in size), which consisted chiefly of an abundance of gypsum flakes, quartz and anhydrite. Also many bits of magnetite and pyrite were observed. Zircon, tourmaline, garnet, and pyrite were noted along with many other minerals 1276

Same as sample from 1276 feet 1280

Same as sample from 1276 feet 1284

Same as sample from 1276 feet except a greater amount of fine sand was noted 1285

An abundance of very fine-grained, pinkish calcareous sand. The sand was composed of a large amount of clear quartz grains (less than .12 mm. in size and being angular in shape). The same minerals as in sample at 1276 feet were noted 1287

Same as sample from 1287 feet 1290

Brownish, slightly calcareous, medium-textured, very sandy clay, having irregular inclusions of the same material except being gray in color. The washed material consisted entirely of a large amount of slightly rose-tinted quartz grains (less than .12 mm. in size). These grains were noted to be angular to subangular in shape, and were considerably etched and worn. Gypsum and magnetite were noted. Same at 1293, 1295, 1298, and 1300 1292

A pinkish sandy, calcareous clay. Large fragments of gypsum were noted. The sand grains were the same as in sample from 1292 feet 1302

Pink, calcareous, very sandy, medium-textured, soft clay. The washed material was composed of a large amount of sand, chiefly rose-tinted quartz grains, being angular to subangular in shape and noted to be between .10 mm. and .16 mm. in size. Many small bits of magnetite were present 1302

Light pink calcareous, sandy, soft clay. The sand was very fine rose-tinted quartz grains 1305

Grayish, slightly sandy, calcareous clay, having white areas of slightly calcareous material noted in the rock. These white areas appear to be kaolin. A small amount of very fine-grained quartz was present, resembling the sand in sample from 1302 feet. Gypsum and magnetite were observed 1313

Same as sample from 1313 feet 1316

Gray, calcareous, sandy, medium-textured clay; sand of very fine clear and slightly rose-tinted quartz grains. Gypsum fairly abundant 1324

Depth in Ft.

Grayish, calcareous, sandy, fine-textured, soft clay. The sand was practically the same as in sample from 1324 feet 1328

Cream-colored, fairly soft limestone, which had been ground to greatly resemble a medium-grained sand when first observed. Gypsum and magnetite present. Same at 1368,

Light, grayish, calcareous sandy, fine-textured, soft clay. Many small, fairly well rounded bits of yellow and gray limestone noted. A small quantity of fine clear quartz grains was noted. Gypsum was present 1338
1369, 1373, 1378, and 1380 1364

Abundant gypsum and cream-colored limestone. The gypsum being in large cleavage fragments. Magnetite was noted. Many limestone fragments were red, caused by iron. Same at 1393 and 1397 1385

Abundance cream-colored, grayish-yellow and pinkish limestone and gypsum. Much of the gypsum was in cleavage fragments, while many small conglomerate masses composed of very minute fragments of gypsum were noted. Fibrous gypsum was abundant. About twenty or more rose-tinted quartz crystals were noted. Tourmaline and magnetite present 1400

Same as sample from 1400 feet, except this sample contained a larger amount of fine quartz grains, chiefly clear quartz, and many of them carried the typical crystal form. Same 1407 and 1410 1404

Abundant gypsum, chiefly in various sized flakes. Magnetite and few quartz crystals were noted 1425

Pink and grayish, slightly calcareous clay, in which was noted a considerable amount of gypsum. Quartz crystals and magnetite present. Same at 1453 1433

Pinkish calcareous clay, containing minute nodules of grayish material and large amount of pink-colored gypsum. Pyrite and very small quartz crystals were noted. Small aggregations of minute gypsum fragments were cemented together by calcareous material. Zircon present. Same at 1455 1451

Gray and pink calcareous, fairly coarse-textured sandy clay containing gypsum and fine sand 1462

Pink, fine-textured, soft, slightly calcareous, sandy clay. The rock appeared to have very small depressions and pores, also small irregular inclusions of grayish calcareous material. Gypsum was noted, fairly abundant. Pyrite was present. Same at 1477, 1480, 1483, 1486, 1491, 1494, 1498, and 1506 1474

Depth in Ft.

Pinkish, calcareous, sandy clay, and gypsum. Typical quartz crystals were noted, both clear rose-tinted. Magnetite was present 1518

Light brownish, calcareous, sandy clay, in which was noted a considerable amount of gypsum, being the same type as in the sample from 1518 feet. Magnetite and tourmaline were noted, also quartz crystals carrying the typical quartz crystal faces. Same at 1523 and 1528 1520

Abundant clear gypsum, also grayish and slightly rose-tinted gypsum. Magnetite and quartz crystals were noted. Same at 1546 1540

Brownish, non-calcareous, sandy clay which had many irregular white areas of salt. Gypsum and very fine quartz was noted. Zircon was present. Same at 1578, 1587, 1590, 1605, 1610, 1625, 1628, 1631, 1635, and 1637 1574

Brown, calcareous, slightly sandy, salt clay, having no coarse texture. Gypsum was present in a small quantity. Same at 1645 1640

Fragments of light cream-colored crystalline dolomite. A large amount of crystalline salt was noted. Magnetite was abundant. Same at 1660 1655

Fragments of grayish, slightly calcareous clay, was present. Same at 1670 and 1675 1665

Pinkish, slightly calcareous clay, in which was noted a considerable amount of salt. Resembles sample at 1574 feet. Same at 1685 and 1690 1680

Abundant crystalline salt. Reddish, slightly calcareous clay was also noted in sample. Same at 1700 and 1705 1695

Crystalline salt, and a small amount of pinkish clay 1710

Abundant white and gray fine-textured anhydrite, and a large amount of crystalline salt. Fragments of magnetite were noted 1723

Pinkish, slightly calcareous clay, which carried an abundance of white salt 1729

Light grayish-pink medium-textured, very salty clay, the salt being both in pockets and distributed through the rock 1735

Same as sample from 1735 feet, except this sample was light pinkish in color 1740

Same as sample from 1740 feet 1746

White and gray granular appearing anhydrite and also white crystalline salt. Same at 1774 1768

White-gray anhydrite, crystalline salt 1780

Large amount of crystalline salt, few fragments of grayish anhydrite, and also a small amount of calcareous material

Depth in Ft.

which often cemented together fragments of salt. Few pinkish fragments, very possibly polyhalite. Same at 1790 1786

Abundant clear white crystalline salt, some whitish and grayish anhydrite. Pink fragments were noted, probably polyhalite. Same at 1795 1795

Whitish crystalline salt 1800

White and gray anhydrite with some white crystalline salt 1805

An abundance of white crystalline salt 1811

An abundance of white crystalline salt, and fragments of gray anhydrite 1823

A large amount of white and gray anhydrite 1833

Chocolate-colored fine soft clay, with a considerable amount of cream-colored and grayish anhydrite. A few minute fragments of yellowish dolomite present. Magnetite abundant 1840

An abundance of grayish and white anhydrite. Gypsum was also noted. A small amount of clear crystalline salt was present 1852

An abundance of clear crystalline salt, white anhydrite was noted, also few bits of gray non-calcareous clay 1894

Same as sample from 1894 feet 1900

Sample consists of an abundance of clear white crystalline salt 1905

Same as sample from 1905 feet, carries a slight pink tint 1911

Same as sample from 1905 feet 1916, 1822, 1928

Sample resembles sample from 1905 feet; grayish anhydrite was noted in small amount 1934

White and light gray anhydrite, also a considerable amount of clear crystalline salt 1939

Same as sample from 1939 feet 1945

Abundant gray, white and cream-colored anhydrite 1951

An abundance of cream-colored anhydrite and gypsum in crystalline form, also a few fragments of yellowish dolomite were noted 1956

An abundance of finely powdered gypsum, also a few very small fragments of cream-colored dolomite 1962

An abundance of white anhydrite, some grayish anhydrite, a few fragments of grayish shale, which carried an abundance of minute bits of pyrite. Three or four yellowish bits of dolomite were noted 1962

Same as sample from 1962 feet 1975

An abundance of gray and white anhydrite, and also gypsum 1982

	Depth in Ft.
Yellowish dolomite, white and cream-colored anhydrite, and an abundance of gypsum, which a large quantity was ground very finely	1987
Same as sample from 1987 feet	1993
Abundant gypsum, also gray and white anhydrite	2000
Same as sample from 2000 feet, except this sample has a considerable quantity of crystalline salt	2006
Same as sample from 2000 feet	2012
Abundant gypsum and grayish anhydrite, being very finely powdered	2018
Same as sample from 2018 feet	2023
White crystalline salt and a few bits of gray anhydrite	2029
White and gray anhydrite, also a considerable amount of gypsum	2036
Same as sample from 2036 feet	2042
Abundant cream-colored gypsum and also fragments of white and cream-colored anhydrite	2048
Very light to dark gray anhydrite, also fragments of yellowish anhydrite were noted	2053
Light brownish-gray and white anhydrite and also gypsum	2063
Same as sample from 2063 feet	2070
Same as sample from 2063 feet, except this sample has a larger amount of gray dolomite and a less amount of the light brown rock	2078
Same as sample from 2053 feet	2094
A large amount of white clear crystalline rock salt	2101
Same as sample from 2063 feet	2127
Sample consists of white crystalline salt	2135
Same as sample from 2135 feet	2142
Same as sample from 2135 feet	2148
Crystalline salt carrying a slight pinkish tint	2155
Same as sample from 2155 feet	2160, 2165, 2170
White crystalline salt	2175
Same as sample from 2175 feet	2185, 2190
White crystalline salt, a few fragments of gray shale were noted, these having considerable amount of very minute bits of pyrite in them	2196
Same as sample from 2196 feet	2202
Abundant white crystalline salt	2214
Abundant white crystalline salt, a larger amount of gypsum, and also cream-colored anhydrite	2218
Abundant fine-textured gypsum fragments and a few fragments of white and cream-colored anhydrite	2222
Abundant finely powdered gypsum, cream-colored, and grayish anhydrite. A small amount of magnetite was noted	2225

Depth in Ft.

Abundant grayish and cream-colored anhydrite, some gypsum and a small amount of salt 2230
Same as sample from 2230 feet 2236
Abundant white crystalline salt, a considerable amount of gypsum and also white, gray and yellow anhydrite 2241
Abundant white crystalline salt, and a few fragments of gray anhydrite and a small amount of gypsum 2246
Abundant cream-colored and a small amount of grayish anhydrite. A large amount of crystalline salt was noted 2253
Abundant gypsum and cream-colored and grayish anhydrite 2260
Abundant gypsum. Some of it in large fragments. Magnetite noted 2268
Abundant gypsum; many fragments were noted to have yellowish color from the magnetite in the sample 2273
Large amount of finely powdered gypsum, which was often noted to be Fe stained 2274
Same as sample from 2274 feet 2276
Abundant putty and grayish-colored dolomite, cream-colored dolomitic limestone, and a large amount of gypsum. Magnetite was present in large quantities, which was noted to have stained many fragments of the different material above mentioned 2280
Same as sample from 2280 feet 2281
Resembles the sample from 2280 feet 2284
Resembles sample from 2280 feet, except a larger proportion of gypsum than dolomite occurs. A small amount of blackish soft shale present in this sample 2285
Abundant white crystalline salt. Few fragments of cream-colored anhydrite, and a small amount of gray (above described) shale was noted 2305
Large amount of clear white crystalline salt 2310
Abundant white and cream-colored anhydrite and gypsum, a few bits of yellowish dolomite, and fragments of grayish shale carrying much gypsum were noted. These possessed a medium-textured appearance 2295
Same as sample from 2295 feet 2300
Abundant clear, white crystalline salt. A few fragments of gray (above described) shale 2315
Same as sample from 2315 feet, except this sample has more gray shale. Very minute bits of pyrite were noted in the gray shale 2320
Abundant clear, white crystalline salt 2325
Abundant crystalline salt, this being slightly tinted yellowish, due to the magnetite 2330

	Depth in Ft.
Abundant clear white crystalline salt. Fragments of gypsum noted	2335
Abundant gypsum and large quantity of cream-colored anhydrite. Magnetite was noted	2344
Abundant gypsum, a considerable amount of cream-colored anhydrite, and numerous fragments of grayish, somewhat crystalline dolomite. A few bits of magnetite was noted	2350
Large amount of grayish dolomitic limestone. A considerable amount of gypsum was noted; also cream-colored and white anhydrite was present	2353
Abundant grayish-brown dolomitic limestone which was noted to come in the mass of the material. A considerable amount of gypsum was noted. Magnetite was present in a fair amount	2356
Abundant gypsum. Fragments of grayish-brown dolomite and bits of white and cream-colored anhydrite present	2360
Large amount of white anhydrite, some gray shale, and a few bits of brownish dolomite	2365
Large amount of white, clear crystalline salt. Few fragments of gray shale present	2367
Same as sample from 2367 feet	2375
Same as sample from 2367 feet	2377
Large amount of grayish fine-textured dolomitic limestone. Gypsum was noted to be present. Very minute cavities were noted in the dolomitic limestone. Magnetite was noted	2385
Same as sample from 2385 feet	2390
Abundant finely crushed, light grayish-brown and yellowish dolomitic limestone	2393
Same as sample from 2393 feet	2396
White, gray, and brown dolomitic limestone. The white dolomite was noted to be composed of very fine crystals of dolomite, giving the rock a very fine-textured sandstone appearance. Magnetite present	2400
Large fragments of gray and cream-colored anhydrite. Small bits of cream-colored dolomite noted	2404
Large number of fragments of gray, brown and cream-colored anhydrite. Bits of yellowish dolomite were noted	2408
Same as sample from 2408 feet	2410
Gray and cream-colored anhydrite. Rock salt was also found present	2414
Gray and brown anhydrite of different shades. Indistinct laminations were noted on some of the fragments	2410

Depth in Ft.

Gray and brown dolomite, and white anhydrite. The dolomite is more abundant 2426
Gray and white anhydrite, also gray and yellowish dolomite. Magnetite present 2429
Same as sample from 2429 feet 2431
White and grayish anhydrite. Magnetite was noted. Sample same as that from 2438 feet, except bits of yellowish dolomite were noted 2442
White and light grayish anhydrite. Magnetite was noted 2446
Yellow and grayish dolomite and white anhydrite and gypsum 2449
Same as sample from 2449 feet 2451
Grayish and white anhydrite and grayish and brown dolomite. Magnetite present 2455
Sample same as that from 2455 feet 2461
Brownish and gray dolomite and an abundance of gypsum. Magnetite present 2471
Abundant white and light grayish anhydrite and bits of brownish and gray dolomite 2477
Abundant brownish and gray dolomite, also a considerable amount of white and cream-colored anhydrite was noted 2481
Large amount of brownish and grayish dolomite, a considerable amount of gypsum and also white and light gray anhydrite. Same at 2497 and 2501 feet 2488
Grayish, slightly calcareous shale, dark brownish dolomite, white and cream-colored anhydrite and gypsum 2513
Many large fragments of grayish dolomitic limestone, and large amount of whitish anhydrite. A few bits of brownish dolomite were noted 2517
Grayish and brown dolomite, also bits of dark brownish, slightly clacareous clay. White anhydrite was noted 2520
Same as sample from 2520 feet 2522
Grayish and light yellowish-brown dolomite, fair quantity of gypsum. Magnetite was noted 2526
Same as sample from 2526 feet 2530
Same as sample from 2526 feet 2533
Abundant fine bits of cream-colored dolomite. Magnetite was fairly abundant. Some fragments of dolomite were stained yellowish 2535
Dark brownish-gray and grayish dolomitic limestone fragments. Magnetite was noted 2540
Practically same as sample from 2540 feet, but composed of smaller fragments 2543
Same as sample from 2543 feet 2545

	Depth in Ft.
Same as sample from 2540 feet, except that white anhydrite is present	2548
Same as sample from 2548 feet	2550
Same as sample from 2548 feet	2552
Same as sample from 2548 feet	2553
Same as sample from 2548 feet	2556
Chiefly yellowish dolomite. Many fragments of gypsum present. Magnetite present	2558
Same as sample from 2558 feet	2562
Large quantity of dark brownish-gray dolomitic limestone. White anhydrite present	2568
Large quantity of brownish-gray dolomitic limestone, white anhydrite and gray shale	2570
Same as sample from 2570 feet	2576
Same as sample from 2570 feet, except no anhydrite was noted here	2578
Large amount of brownish-gray dolomite, a considerable amount of white anhydrite, and many fragments of gypsum. Magnetite present	2581
Same as sample from 2581 feet	2583
Same as sample from 2581 feet	2586
Same as sample from 2581 feet, except this one does not have gypsum	2595
Fine-textured brownish-gray dolomite, which was broken in very small bits, a small amount of white anhydrite and magnetite were noted	2600
Abundant clear white anhydrite crystals, and a considerable amount of light brownish dolomite. Magnetite was noted	2603
Abundant brownish-gray dolomitic limestone fragments. Magnetite was noted	2608
Same as sample from 2608 feet	2612
Same as sample from 2608 feet, except few fragments of white anhydrite were noted	2616
Same as sample from 2616 feet	2620
Considerable amount of white and grayish anhydrite, and grayish dolomite. A few bits of grayish, slightly calcareous clay present. Magnetite present	2627
Chiefly an abundance of pinkish colored and cream-colored anhydrite. A considerable amount of red calcareous clay and a few small fragments of grayish dolomitic limestone were noted. Same material at 2741, 2753, 2758, and 2763	2736
Abundant finely powdered gypsum and also bits of finely crumbled pinkish anhydrite	2769

	Depth in Ft.
Abundant pinkish and dark red anhydrite, also many fragments of dark reddish, slightly calcareous clay	2776
Same as sample from 2776 feet	2784
Abundant dark reddish, slightly calcareous, slightly sandy shale. Gypsum and magnetite were noted. About thirty or forty rounded dull quartz grains between .28 and .40 mm. diameter were noted. A small amount of very fine pink and dull quartz grains is present	2792
Practically the same material as sample from 2792 feet, except an abundance of reddish crystalline anhydrite was noted in this sample	2796
Same as sample from 2796 feet	2799
Dark reddish, slightly calcareous sandy clay. Also many large fragments of pinkish anhydrite was noted. In the washed material a large quantity of very fine angular to subangular, clear and rose-tinted quartz grains was noted, the mass of the material being less than .15 mm. in size. A few large rounded dull quartz grains noted. Magnetite fairly abundant	2804
Fragments of gray dolomitic limestone, pinkish anhydrite and also a fair amount of reddish slightly sandy shale	2809
Pinkish, soft, slightly calcareous clay. A few bits of pink and white anhydrite were noted	2815
Sample consists chiefly of an abundance of gypsum, also a large number of fragments of grayish dolomitic limestone. Magnetite was noted	2819
Pink, soft, fluffy, slightly calcareous clay. Only a very small amount of fine sand grains was contained in the sample	2822
Chiefly an abundance of very fine gypsum crystals, also a considerable amount of pinkish calcareous clay was noted	2828
Same as sample from 2828 feet, except fragments of gray dolomitic limestone were noted also in the sample	2834
Chiefly fragments of gypsum, some white, cream-colored and pink anhydrite, reddish calcareous clay, and a few bits of gray dolomite. Magnetite was present	2838
Chiefly grayish dolomitic limestone, a large amount of gypsum and reddish calcareous clay was also noted	2843
Grayish hard dolomitic limestone	2846
Chiefly gray and brownish dolomitic limestone; gypsum was also fairly abundant	2852
Abundant gypsum also brown and grayish dolomite. Magnetite was present	2856
Same as sample from 2856 feet	2860
Same as sample from 2856 feet	2867

Depth in Ft.

Fragments of red shale, and an abundance of gypsum. The gypsum was deposited in thin layers in the red shale; this could be observed in several of the larger fragments of shale. Magnetite fairly abundant 2872

Gray dolomitic limestone, also an abundance of red shale and gypsum was noted. Magnetite was present 2877

Abundant reddish, slightly calcareous, sandy shale, also a large amount of cream-colored and grayish fragments of dolomitic limestone, gypsum was noted in quantity. In the washed sample was found poorly sorted dull and clear quartz grains, a few large round grains were noted, and the remainder of the sand was rose-tinted and clear quartz, being from angular to subangular in shape. Magnetite was noted in fair abundance 2882

Abundant grayish and cream-colored dolimitic limestone, and also bits of reddish, sandy, slightly calcareous clay. Magnetite noted 2887

Grayish hard dolomitic limestone 2889

Pinkish, calcareous, slightly sandy clay, in which a considerable amount of small bits of grypsum was noted 2892

Chiefly large fragments of reddish crystalline gypsum, also cream-colored and pinkish gypsum was abundant. Many fragments of reddish, sandy, slightly calcareous clay was noted. These reddish fragments often contained small areas of grayish material of apparently the same material as the reddish, except differed in color. The sand was poorly sorted, being practically the same as found in sample from 2882 feet 2892

Abundant red, sandy, very slightly calcareous clay, also an abundance of reddish-white and cream-colored gypsum was noted. The sand was poorly sorted, the mass being chiefly less than .16 mm. in size, both rose-tinted and clear, subangular to angular-shaped quartz. Possibly fifty or more rounded, dull quartz grains about .28 mm. in size. Magnetite present 2902

Sample resembles sample from 2902 feet, but this sample has a little less reddish clay, but more reddish gypsum, and more grayish areas in the red clay. The sand was practically the same as sample from 2902 feet 2907

Pinkish gray, soft calcareous clay, amount of gypsum. Bits of gray dolomite present 2965

Abundant grayish-brown dolomitic limestone, also a large amount of fragments of gypsum and cream-colored anhydrite. Magnetite noted 2973

	Depth in Ft.
Pinkish, soft, very slightly calcareous clay, in which was noted bits of gypsum	2980
Same as sample from 2980 feet	2985
Same as sample from 2980 feet	2991
Sample consists chiefly of an abundance of grayish and cream-colored dolomite, a great amount of the dolomite being finely powdered. Gypsum was also noted	3000
Same as sample from 3000 feet	3011
Pinkish-brown, very soft, calcareous clay. Gypsum was noted in the clay	3019
Pinkish, soft, calcareous clay, in which a large amount of minute bits of gypsum was noted	3028
Abundant fragments of gypsum, a considerable amount of reddish calcareous clay. Fragments of grayish dolomite present	3032
Chiefly of a large amount of pinkish and white anhydrite fragments and reddish calcareous sandy clay. A few bits of gray dolomite were present	3036
Pink, soft, very fine, highly calcareous clay. Fragments of white anhydrite was noted	3041
A large amount of gypsum, white and pink anhydrite, and brownish dolomite	3046
Same as sample from 3046 feet	3055
Finely ground, grayish and cream-colored dolomite. A considerable amount of gypsum was also noted	3058
Fragments of grayish dolomitic limestone. Gypsum present	3061
Same as sample from 3061 feet, except a much larger quantity of gypsum was noted, and also anhydrite	3066
An abundance of gypsum fragments, and some white anhydrite; also a few bits of cream-colored and grayish dolomite was noted. Many grayish fragments of what appeared to be grayish sandstone, but which was composed of minute bits of anhydrite cemented together by grayish clay	3073
Pinkish, very fine-textured, soft clay, in which was noted minute bits of gypsum	3095
A large amount of fragments of gypsum, white anhydrite. Grayish and yellowish dolomite present	3102
Sample consists of an abundance of cream-colored, soft dolomite, and a large amount of gypsum. Many fragments of gray and brown dolomite were noted	3109
Chiefly grayish-brown dolomite, also a large amount of fragments of gypsum and white anhydrite. Fragments of greenish dolomite were noted	3118

	Depth in Ft.
Greatly resembles sample from 3109 feet	3146
Many fragments of grayish material resembling "sandstone," which was practically the same as the rock described in sample from 3073 feet. Bits of grayish dolomite present	3151
Abundant white and cream-colored anhydrite, brownish, calcareous clay, and fragments of grayish dolomite	3158
Abundant grayish dolomite and white anhydrite	3158
Pinkish, soft, fine-textured, calcareous clay. Gypsum present	3173
Abundant cream-colored and pinkish anhydrite, and reddish calcareous clay. A considerable amount of gray dolomite and also bits of gray calcareous clay were noted	3177
Chiefly cream-colored and grayish dolomitic limestone. White and pink anhydrite, and pink and gray, slightly calcareous clay present	3183
Chiefly cream-colored and grayish dolomitic limestone. White anhydrite and pinkish gray, very slightly calcareous clay present in small quantity	3189
Fairly large fragments of light gray, and some dark gray dolomitic limestone. Magnetite present	3195
Chiefly fragments of medium gray dolomitic limestone, and some fragments of darker gray dolomitic limestone	3195
Dark grayish dolomitic limestone	3204
Chiefly medium and dark gray dolomitic limestone. Grayish calcareous clay, and white anhydrite were noted in small quantity	3209
Sample same as that from 3209 feet	3214
Chiefly grayish, appearing to be sandstone, but which consists of very minute bits of crystals of anhydrite cemented together by calcareous material. Considerable gray dolomite present	3219
Chiefly an abundance of fragments of white anhydrite and also the "sandstone appearing type" as described in sample from 3219 feet. A few bits of cream-colored dolomite present	3226
Dull yellowish calcareous clay, being quite soft and having a medium texture	3226
Chiefly an abundance of light grayish and white anhydrite. Many fragments of grayish "appearing to be sandstone," but is composed of very minute bits and crystals of whitish anhydrite, these being cemented together by a slightly calcareous material. A few fragments of grayish dolomite were noted	3233

Depth in Ft.

Chiefly medium grayish and pinkish dolomitic limestone, a considerable amount of reddish calcareous clay and cream-colored anhydrite present 3241

Chiefly light grayish dolomitic limestone. Fragments of white anhydrite and a few fragments of pinkish slightly calcareous clay present 3248

Same as sample from 3248 feet 3260

Light yellowish-gray, soft, fine-textured, powdered, calcareous clay 3260

Large fragments of brownish-gray dolomitic limestone 3268

Abundant fragments of light grayish dolomitic limestone and light grayish-white anhydrite. Many fragments of anhydrite were noted to be composed of minute crystals of anhydrite cemented together by a non-calcareous clay 3274

Sample resembles sample from 3274 feet, a large amount of magnetite noted 3277

Grayish dolomitic limestone which carried a tint of yellow and brown, due to the abundance of magnetite contained in the sample. Fragments of the dolomitic limestone were yellowish and some cream-colored 3282

Same as sample from 3282 feet 3286

Light grayish-white and grayish dolomitic limestone. Magnetite abundant, stains many fragments of dolomitic limestone yellowish 3292

Same as sample from 3293 feet 3298

Large fragments of dolomitic limestone, ranging in color from light grayish-white to dark grayish. The lighter grayish dolomitic limestone is crystalline 3304

Dark and medium gray dolomitic limestone 3307

Light grayish white to medium gray dolomitic limestone, most of the light grayish white dolomitic limestone was noted to be crystalline 3312

Light grayish to medium gray dolomitic limestone. The dolomitic limestone is somewhat fine-textured and crystalline 3318

Light gray medium brownish-gray and dark gray dolomitic limestone. Magnetite was abundant 3323

Chiefly very fine grains of subangular to angular dull quartz, and also fine grains of white and cream-colored dolomite, these being cemented together by a calcareous material. Also many fragments of grayish and light grayish-brown dolomitic limestone were noted 3329

Same as sample from 3329 feet 3334

Same as sample from 3329 feet 3338

Dark gray, calcareous sandy shale. In the washed sample a fair quantity of well sorted subangular to chiefly angu-

Depth in Ft.

lar-shaped, dull quartz grains noted, these being less than .12 mm. in size. Mica was noted in abundance. Magnetite was present. Also a grayish, calcareous, micaceous sandstone noted in abundance, the sand grains being the same as those found in the shale 3351

Same as sample from 3351 feet 3352

Chiefly grayish sandy, calcareous shale and buff-colored, calcareous fine-grained sandstone, in which a considerable amount of magnetite present. In washed material the sand grains were well sorted, dull quartz, being less than .15 mm. in size and from angular to subangular in shape .. 3363

Same as sample from 3363 feet 3369

Same as sample from 3363 feet 3376

Dark grayish, sandy buff-colored, fine-grained, calcareous sandstone. Magnetite abundant. The washed material was same as sample at 3363 feet 3382

Soft silty, buff-colored, sandy, slightly calcareous clay. The sand grains were very fine, dull, evenly sorted quartz .. 3388

Grayish, calcareous, fine-grained sandstone. Fragments of white dolomitic limestone were noted. The washed material consisted chiefly of clear, well sorted quartz, being less than .15 mm. in size, and from angular to subangular in shape. The grains appeared considerably etched. Deleware Formation (?) 3388

Fragments of grayish dolomitic limestone. Magnetite was noted. Some grayish, sandy calcareous shale was present .. 3395

Same as sample from 3395 feet 3398

Chiefly greenish-gray clay, which carried greenish irregular lamination, appearing areas. Grayish dolomitic limestone was also noted. Magnetite was present 3401

Fragments of grayish dolomitic limestone and greenish-gray shale 3405

Same as sample from 3405 feet 3408

Fragments of grayish dolomitic limestone 3412

Fragments of grayish dolomitic limestone and greenish-gray shale 3415

Same as sample from 3415 feet 3417

Same as sample from 3415 feet 3421

Same as sample from 3415 feet 3424

Same as sample from 3415 feet 3427

Finely ground bits of gray dolomitic limestone and greenish-gray shale 3429

Same as sample from 3429 feet, except the material was composed of larger fragments 3432

Medium-sized fragments of grayish dolomitic limestone 3437

Log and Descriptions of Samples from Downie Water Well. S. E. Ligon Drilling Co. Section 18, Block R4, 5 Miles Northeast of Longfellow. Submitted by Chas. Downie, Sanderson, Texas

Formation:	Depth in Ft. From	To	Thickness
White and yellow lime	0	240	240
Blue Lime	240	245	5
Yellow sand, porous and leaky in spots	245	368	23
Blue lime, leaky also in places	368	635	267
Black lime or slate	635	710	75

Description of Samples by J. A. Udden

	Depth in Ft.
Black shale considerably harder than any Cretaceous shale or marl from this region. With this shale is some sand in which the grains are in part enlarged by secondary crystalline accretion. Some pyrite present. The shale is entirely non-calcareous. In closed tube gives weak bituminous fumes. No ammonia noted. The shale has decidedly the appearance of the Tesnus shale	710
Sample consists of a black sandy shale, somewhat indurated. This shale is non-calcareous. In thin section the larger sand grains seem to be mostly angular. In closed tube test, the shale gives off fumes of bitumen. It turns light grey after ignition. The shale resembles the Tesnus formation	815
Dary grey sandstone, which varies from pure white, in small areas, to black. It contains numerous dark streaks and dark finer grained areas. Most of the sand grains are large and many have secondary crystal faces. Some pyrite. A few pieces of coal also noted, but these are probably of foreign particles. Heated in closed tube faint fumes of ammonia and bitumen are given off	870
Sample consists of black indurated, non-calcareous, sandy shale containing crystals of pyrite and calcite. One fragment was seen to contain a number of quartz crystals. In closed tube yields fumes of ammonia. (Tesnus) Pennsylvanian	1170

Log of Henry Findeis' Well in Pecos County

Formation: (according to driller).	Depth in Ft. From	To	Thickness
Red beds, lime (honey-combed) sand, had water increasing to 550 feet. Flowing about 300 gallons per minute. Strong sulphur odor, not very salty		550	550
Native sulphur	550	850	30
Strong gas, shooting water 18 hours 18–30 feet in air. Sand	850	860	10
Sand and lime. Sand quartz, carrying oil. Thickness estimated solid sand, 10 feet	860	1000	40

Description of Samples from Findeis, Bower and Lamb No. 1, Section 592, Pecos County. Submitted by F. R. Campbell, Fort Stockton, Texas. Described by J. A. Udden

	Depth in Ft.
Two samples of rock measuring each about 1½x¾x½ inch consisted of layers of gray limestone alternating with layers of yellow sulphur in one and layers of somewhat clear calcite in the other. One of the flat sides on each was covered by a one-sixteenth inch layer of white calcite crystals with free outer ends. This layer was evidently free surface in a cavity in the rock. Texture of the limestone was irregular as seen in thin section. Lamination was somewhat crumpled	855
Grey dolomitic limestone, with some white limestone. In thin section the gray limestone seems to be very fine in texture and to contain angular grains of quartz. It also has areas of crystalline calcite	860
Sample consists of material too finely ground up for making of thin section. At least three-fourths of sample consists of crystalline calcareous material. Some of this is in the form of columnar acicular crystals of calcite. The remainder is for the most part worn sand with some anhydrite	860

Log and Description of Samples from Fort Stockton Syndicate No. 1, 175 Feet from East Line and 175 Feet from South Line, Section 602, P. H. Fall Survey. Elevation 2667 Feet T. D. 1162 Feet. Abandoned. Shot: Two Hundred Quarts 1115 to 1065 Slight Increase in Show of Oil. Casing Record: 84 Feet 12⅛-Inch; 574 Feet 10-Inch

Formation:	Depth in Ft. From	To	Thickness
White marl water	———	23	23
Hard brown lime	23	36	13
White mud, water	36	57	21
Gravel, water	57	59	2
Hard brown sand	59	67	8
River gravel, water	67	68	1
Red shale	68	117	49
Blue gray shale	117	192	75
Sandy blue shale	192	205	13
Gray shale	205	207	2
Gray lime with shale breaks	207	234	27
Gray shale	234	237	3
Gray lime	237	331	94
Blue and red sand, artesian water	331	350	29
Blue sand	350	370	20
Gray lime	370	375	5
Brown lime	375	390	15
Gray lime, gyp and anhydrite at 530	390	570	180
Yellow lime	570	580	10
Gray lime, gyp and anhydrite	580	620	40
Gray and brown lime	620	650	30
Gray and blue lime	650	690	40
White lime	690	710	20
Gray and blue lime	710	720	10
White and gray lime	720	740	20
Brown lime, gyp and anhydrite	740	750	10
Brown lime with blue clay breaks	750	760	10
Gray and brown lime	760	770	10
White lime and gray shale breaks	770	780	10
Hard white lime	780	790	10
White and gray lime	790	800	10
Hard lime with sand breaks	800	810	10
White and gray lime	810	820	10
Hard blue lime	820	970	150
No log	970	980	10
Blue clay	980	990	10

Formation:	Depth in Ft. From	To	Thickness
Green shale	990	1010	20
Gray lime	1010	1020	10
White shale	1020	2030	10
Shale and lime with oil show	1030	1040	10
Gray lime	1040	1065	25
Sandy lime, some oil and gas	1065	1115	50
Hard gray lime	1115	1162	47

Description of Samples Submitted by Judge Wm. Blakeslee, 711 Littlefield Bldg., Austin, Texas. Described by E. B. Stiles, April 1, 1921

Depth in Ft.

Sample consists principally of gray anhydrite. With this is some slightly greenish, yellowish-brown silt and very fine sandstone. No fossils were seen in this material. Pyrite present.. 1010

Mostly gray anhydrite with some slightly greenish-blue shale. Occasional worn sand grains and a quartz crystal were seen in washed material. No fossils noted. Pyrite present..... 1020

Mostly white and light gray anhydrite with some greenish-blue gray shale. Pyrite, some gypsum, and an occasional quartz grain noted in washed material. An imperfect quartz crystal was seen 1030

White and gray anhydrite, dolomite in shades of greenish-yellow and brown and some fine sandstone like that mentioned from 1010 feet. Two distinct flakes of mica were seen, one in a fragment of sandstone and the other in a fragment of shale. Pyrite and sulphur fumes were noted..... 1040

Sample consists chiefly of white to light gray anhydrite with some fibrous and brown dolomite and some gypsum. In thin sections the dolomite shows imbedded small sand grains. Other sections show traces of organic fragmental or oolitic texture 1060

Brown and bluish, mostly fine-grained dolomite, showing traces of organic fragments, and sandy dolomite with some white anhydrite. Worn quartz grains and pyrite noted. In closed tube, sulphur fumes and bitumen sufficient to make a deposit in the tube and to sustain a very slight flame, were noted..... 1080

Brown and bluish-gray dolomite, some of which is sufficiently sandy to be classed as a dolomitic sandstone. Some worn sand grains and a quartz crystal were noted. Pyrite present. In closed tube sulphur fumes and strong bituminous fumes were given off. A slight deposit was formed in tube..... 1085

Brown and bluish and yellowish-gray dolomite and dolomitic sandstone. There is a considerable increase in the amount of

Depth in Ft.

sand in this sample. In thin section a single fragment will show both fine textured dolomite and sandstone. Pyrite and some anhydrite noted 1087

Bluish-gray fine-textured dolomite, gray, very fine-textured dolomite, and brown and white crystalline to granular dolomite. This dolomite shows traces of organic fragments in that it consists of blotched rounded and irregular areas of fine texture surrounded by material of coarser texture. The very fine-textured rock contains small pyrite crystals and a dark green material resembling glauconite. In thin section some fragments show a fine crystalline texture with irregular darker areas and apparently with some porosities(?). Anhydrite and some sand and sandstone present. In closed tube strong bitumunous fumes forming a slight deposit in tube were noted 1088

Brown sandy dolomite and fine-textured bluish-gray and gray dolomite. Some fragments show small porosities. In thin section the brown rock shows a granular texture with imbedded sand grains while the fine-textured rock is very uniform in texture. Some fragments of the rock show small stains which are thought to be bitumen. Some anhydrite and pyrite present. In closed tube bituminous fumes formed a good deposit of oil and sustained a slight flame 1090

Rather dark brown somewhat porous bituminous dolomite and finer grained dark bluish-gray dolomite. The sandstone which has been noted in previous samples seems to be absent at this level. Some pyrite noted. In closed tube bitumen sufficient to form a heavy deposit and support a good flame was given off 1091

Brownish-gray moderately fine-grained dolomite, some of which contains some fine quartz grains. In thin section some fragments show sharply defined, small circular area of clear crystalline material and irregular blotches and streaks of a darker color than the body of the rock. In closed tube bitumen flame at end of tube was given off 1095

Bluish-gray and brown dolomite. In thin section the rock shows a moderately fine texture, with areas of crystalline material and darker irregular areas. A considerable number of quartz grains are seen imbedded in the rock. In closed tube bitumnous fumes and fumes of sulphur were given off 1098

Bluish-gray fine-grained dolomite containing pyrite and quartz grains. In thin section some fragments show imbedded quartz grains, while others have areas of crystalline material and irregular, evidently organic tube-like forms outlined by darker material. In closed tube sulphur fumes were noted 1100

Depth in Ft.

Brown, rather coarse-grained dolomite and bluish-gray fine-textured dolomite. In thin section the fragments are seen to be of even uniform clear coarse-granular texture. Pyrite noted. In closed tube strong sulphur fumes and bitumen sufficient to form a deposit in tube were given off 1103

Gray, dark gray and bluish-gray dolomite. The gray and dark gray rocks are apparently of coarser texture than the bluish rock and contain considerable bitumen in the form of thin films between the grains. Some sharply defined minute rings noted in section. Some fine quartz grains and an occasional worn sand grain present. Pyrite abundant. In closed tube strong sulphur fumes and faint bituminous fumes were given off 1110

Light brown and bluish-gray dolomite, fairly uniformly crystalline. In thin section the rock is seen to contain considerable sand in an even coarse granular texture. Some fragments show irregular dark areas of material of finer texture than the surrounding rock body. In closed tube, bituminous fumes and strong sulphur fumes were given off 1110

NOTE.—Still in Permian at this depth. E. B. Stiles.

Description of Samples from Hale, Bower and Lamb, No. 1, Section 24, Block 26, University Lands, Pecos County. Submitted by F. R. Campbell, Fort Stockton, Texas. Described by J. A. Udden

Depth in Ft.

Yellowish-gray dolomitic limestone with some gypsum and anhydrite 1330

Yellowish dolomitic limestone containing some anhydrite crystals, a little gypsum. Gives strong test for sulphur in closed tube 1334

Buff, dolomitic limestone, containing some gypsum and pyrite, and giving strong test for sulphur in closed tube. No fossils noted 1340

Log and Description of Samples from Menzie No. 1 by Fort Stockton Pioneer Co., 1628 Feet from East Line, 725 Feet from North Line, Section 51, Block C-4, G. S. & S. F. Elevation 2820 Feet. Dry and Abandoned

Formation	Depth in Ft. From	To	Thickness
Surface soil	----	2	2
Chalky marl	2	65	63
Lime	65	145	80

Formation:	Depth in Ft. From	To	Thickness
Blue shale	145	170	25
Lime	170	320	150
Sand	320	420	100
Shale	420	425	5
Red rock and sand	425	525	100
Pink slate	525	535	10
White shale	535	555	20
Red rock	555	572	17
Lime	572	577	5
Red rock	577	591	14
Lime	591	595	4
Red rock	595	628	33
Sand	628	663	35
Red rock	663	807	144
Lime	807	837	30
Red rock and lime shells	837	897	60
Lime	897	922	35
Salt	922	962	40
Lime	962	1119	157
Salt	1119	1389	270
Lime	1389	1414	25
Salt	1414	1534	120
Red conglomerate	1534	1579	45
Sand	1579	1629	50
Lime	1629	1665	36
Salt and sand	1665	1675	10
Sand	1675	1690	15
Lime	1690	1722	32
Sand	1722	1734	12
Lime	1734	1748	14
Sand	1748	1754	6
Shale	1754	1759	5
Gyp and lime	1759	1809	50
Sand	1809	1814	5
Sandy lime	1814	1939	125
Gyp and lime	1939	1976	37
Gray lime	1976	1991	15
Gyp and lime	1991	2266	275
Gray lime	2266	2286	20
Gyp and lime	2286	2306	20
Lime	2306	2396	90
Sand	2396	2407	11
Lime, show gas	2407	2427	20
Sandy lime, show oil	2427	2444	17

Formation:	Depth in Ft. From	To	Thickness
Sand and shale	2444	2448	4
Sand, show oil	2448	2468	20
Lime	2468	2600	132
Sand, show oil	2600	2645	45
Sand lime	2645	2938	293
Sand	2938	2953	15
Lime	2953	3053	100
Sand	3053	3098	45
Lime	3098	3120	22
Sand shale	3120	3138	18
Lime	3138	3454	316
Black lime	3454	3474	30
Lime	3474	3494	30
Brown lime	3494	3642	248

Supplementary log. Note by H. L. Baldwin: Original of the Menzie log in handwriting says this is the remainder of the log of Menzie No. 1 beginning with 2368–2500 feet from the other log.

Lime	2368	2500	132	
Sand	2500	2545	45	
Lime and sandy lime	2545	2838	293	oil show at
Sand	2838	2853	15	2830
Lime	2853	3015	162	
Sand	3015	3025	10	
Lime	3025	3125	100	
Sand, light	3125	3155	30	
Sand, black	3155	3170	15	
Lime	3170	3190	20	
Sandy shale	3190	3210	20	
Light sand	3210	3240	30	? as original
Lime	3240	3556	316	
Lime, black	3556	3576	20	
Lime	3576	3596	20	
Lime, brown sandy	3596	3745	149	

Description of Samples by J. A. Udden

	Depth in Ft.
Light cream-colored dolomitic limestone of moderately fine texture. Some large fragments are etched, apparently coming from some cavernous opening. A few fragments of anhydrite, and also a few fragments of "red bed" rock noted	2640–60
Very light, almost white dolomitic limestone of moderately fine texure. Some fragments of a reddish-brown non-calcareous material and some anhydrite present	2660–80

	Depth in Feet
White dolomitic limestone of fine texture containing a small ingredient of anhydrite. Some small concretions of salmon red gypsum present. Some of the rock shows small porosities in a thin section. The anhydrite in one thin section evidently is present as a replacement in the rock	2690–95
Light, almost white, in part porous, dolomitic limestone of fine texture containing a small ingredient of anhydrite. Obscure traces of rounded organic bodies appear in a thin section of the rock by difference in the crystalline texture. A very small fragment of a Fusulina(?) noted. Some light pinkish material shows crystallization on the exterior and contains some anhydrite	2680–90
White, in small part light bluish-gray dolomitic limestone, of very fine texture. In thin section the original rock is seen to have an obscurely and minutely lumpy texture, and to be in part replaced by anhydrite	2695–2705
Light cream-colored dolomitic limestone of fine texture containing a small ingredient of anhydrite and a small amount of crystalline limestone. In thin section the crystalline limestone is seen to be replacing the original rock leaving areas that suggest organic fragments in their outlines	2705–30
Light cream-colored dolomitic limestone of moderately fine texture containing some anhydrite. In thin section the anhydrite is seen to be replacing the original dolomite. The anhydrite occurs both in patches and in veins surrounding small lumps of the original material in the rock. A small fragment was found which in thin section was seen to have a texture somewhat *like* that in a Stromatopora	2730–45
White dolomite of fine texture, showing some replacements by anhydrite	2745–2760
Dolomitic white limestone of fine texture. In thin section it is seen to be granular with imbedded organic fragments and with irregular small spaces of more coarsely crystalline texture. There are also pockets filled with anhydrite. A Fistulipora(?) with very small cells noted. Some fragments are dark from the presence of bitumen, as shown by heating in a closed tube	2766
Light gray dolomitic limestone containing minute cavities filled with anhydrite. In thin section the rock is seen to be somewhat porous. These porosities are to some extent filled with bituminous material giving the rock a dark, spotted and streaked appearance. Upon heating in the	

Depth in Feet

closed tube a deposit of oil is made in the tube. In thin section the rock appears to have been originally possessed of a microscopic nodular texture in which the interstices have been enlarged and filled with anhydrite. A few small concretions of pyrite present 2765–70

White, very fine grained dolomite, containing some anhydrite 2776

Very light gray dolomite containing some anhydrite. This sample resembles the preceding sample but contains less bituminous material. When heated in closed tube a strong bituminous odor is noted but no deposit is made on tube 2780

Light, almost white dolomite, containg a small ingredient of anhydrite. Some fragments show bituminous deposits in small porosities 2780–95

Light cream-colored dolomite containing a small ingredient of anhydrite. Some fragments show minute porosities filled with bituminous material 2810

Very light, almost white dolomite, containing a small percentage of anhydrite. A few fragments of reddish brown sandstone noted 2825

White dolomite, containing a small percentage of anhydrite. Pyrite present 2840

Gray arenaceous dolomite containing some anhydrite. In thin section the rock is seen to contain angular sand grains in a finer-textured matrix 2850

White dolomite containing some anhydrite. In thin section it is seen that the anhydrite is replacing the original dolomite in spots and veins. Obscure traces of organic fragments noted 2860

Very light gray, almost white dolomite 2865

Very light gray dolomite containing an ingredient of anhydrite. A salmon-colored fragment of anhydrite noted 2870

Light, almost white dolomite, containing anhydrite. No fossils noted 2880

White dolomite slightly discolored by iron oxide, containing anhydrite. Minute porosities in the dolomite are partly filled with bituminous material. A fragment with minute rectangular porosities noted 2900

White fine-grained dolomite containing much anhydrite 2905

White fine-grained dolomite, showing microscopic rounded cavities filled with anhydrite 2910

Light cream-colored to white dolomite, containing anhydrite. A small fragment of salmon-colored anhydrite

	Depth in Ft.
noted. A few fragments contain minute porosities filled with bitumen	2920
Light cream-colored dolomite, containg anhydrite	2930
Cream-colored dolomite containing anhydrite. A small smooth, cylindrical fragment noted	2960
White dolomite containing some anhydrite	2985
Very light gray, almost white dolomite. Traces of organisms were present in this sample. A partially pyritized ostracod(?) and a ridged stem noted	3000
Dolomite, probably light gray to white. Iron oxide discoloration very pronounced. Sample contains anhydrite and and some gypsum, probably due to re-crystallization of minerals in water. Pyrite present	3010
Light gray to white dolomite, containing anhydrite and pyrite	3010–3035
Sample consists of fine brownish quartz sand containing much salmon-pink and fibrous white gypsum and a small amount of calcareous material. The larger part of the sand grains are between one-fourth and one-eighth millimeter in diameter. No fossils were seen. One selenite crystal noted	3670
Dark, fine-grained dolomitic limestone, containing some anhydrite and some very fine grains of quartz. Sponge spicules noted. With this were some fragments of red anhydrite rock. The material deposits oil in closed tube, on being heated gives strong ammonia fumes. Evidently Word formation	3740

Description of Samples from the Reilly Texas Acreage Company's Noelke Well No. 1, Located Northeast Corner of Section 4, Block 193, Texas-Mexican Ry. Co. Survey, 1½ Miles West of Sheffield. Description by J. A. Udden

	Depth in Ft.
Pink sand with some white limestone. In thin section the limestone is seen to contain very minute sponge spicules(?) and minute spherical tests, probably of Globigerina(?). It is of very fine texture	200–250
Bluish-gray sandstone of fine texture with some pieces of white limestone. Pyrite and stains of manganese noted. In thin section the white limestone is seen to be very finely granular and to contain some very small sponge spicules. (Cretaceous?)	250–260
Grey limestone and light-grey anhydrite	390–395

	Depth in Ft.
Dark grey and light grey anhydrite. Pyrite noted. Fragments of a small Ostrea	527–595
Grey sandstone, poorly sorted, with a loose calcareous cement. Many clear salt crystals present. It contains many black grains and larger nodules. There are some small, brownish, spherical concretions present, about one-fourth mm. in diameter. Fossils: black lignite and fragments of oyster-like shells	590– 820
Dark, marly shale and sandy limestone and much anhydrite. The sandy limestone contains some dark grains and small rounded lumps. In thin section it presents very variable texture, from finely granular to shell brecciated texture. some pink-colored anhydrite present. Fossils noted: fragments of shells, smooth-shelled ostracods, Syringopora(?) of small diameter	590–820
Mostly grey anhydrite with some limestone. Some pieces of anhydrite have a spherical (oolitic?) texture, the spherules measuring about a half mm. in diameter. Other fragments of anhydrite show a network of elongated crystals. With the anhydrite is a grey marly clay or shale in which are fragments of fossils. The sample also contains a dirty grey, porous, soft, and fine-grained rock which is essentially anhydrite, and contains considerable salt. There are also fragments of bright salmon-red anhydrite. Fossils: many fragments of oyster-like small pelecypods, one of which showed an attachment area. Mesozoic	850
White and light grey anhydrite. Two small shell fragments noted like those in preceding samples	855–860
Sand or sandstone. The grains are mostly from one-fourth to one mm. in diameter and are most perfectly rounded and polished. With this sand occurs a number of fragments of pelecypod shells, flakey in structure as if worn to pieces from small oysters. Two specimens of ostracods, resembling a Bythocypris noted	1055–1090
Like the material from 1055 to 1090 feet	1060–1090
Gray marl and yellow and pink limestone. Considerable gypsum and some gray sandstone. Small fragments of mollusk shells noted. Possibly a phase of Permian red beds. J. A. U.	1100
White and pink anhydrite	1348–1355
Mostly brown-red anhydrite rock with some white anhydrite. Some fine sand present in the red anhydrite rock	1370–1425
White anhydrite and trace of red clay	1425
Dark brown anhydrite containing much fine sand. Some mica present. Considerable white and pink anhydrite	1428–1447

	Depth in Ft.
Red silt rock and anhydrite, in part, in intimate mixture and in part in separate fragments. Driller's note: "50 or 60 feet stratum"	1480
Delicate pink and white anhydrite	1490–1525
Pure white and pink anhydrite	1490–1525
Indurated silt of typical "red bed" color and aspect. Some light grey limestone of very fine texture	1820–1835
Grey and impure dolomite. In thin section the grey dolomite is seen to consist of a lumpy structure	1835–1870
White dolomite, very compact and microscopically lumpy in texture. Some pink dolomite of same texture	1885–1960
White dolomite(?) having a tendency to break with right angles. After being heated or charred with sodium bicarbonate it leaves a dark stain on silver, indicating the presence of sulphur, probably from anhydrite. In thin section it is seen to be fine-grained. Some pink-colored fragments present	1920
Dark grey, light grey, purplish, brown and greenish, impure and dolomitic limestone. In thin section it is seen to be very fine-grained and does not show clear crystallization as in most dolomite. Some dark brown "red bed" shale and occasional fragments of anhydrite	1965–1972
Very dark light grey, purplish and greenish limestone of fine texture. The darkest fragments have bituminous streaks. Some vari-colored shale present. Minute quartz crystals noted. Some anhydrite noted	2019–2030
Very dark brown, slightly calcareous "red bed" rock. Anhydrite and some greenish blue shale present	2040–2115
Red shale with grey sandstone. Some rounded quartz sand grains noted. Considerable anhydrite present. No fossils noted. Minute quartz crystals noted	2115–2135
Dark red silt rock with red-speckled dolomite mingled with anhydrite. Some bright green shale present. In thin section the red-speckled dolomite is seen to contain many angular quartz sand grains	2120
White sandstone with a copious matrix of hard calcareous material	2135–2140
White sandstone with a copious matrix of dolomite. A few fragments of dark purple shale present. Driller's note: "lime, very hard, turned to sand"	2145
Yellowish hard rock, consisting of a mixture of dolomite and angular quartz sand. A fragment of brown shale present	2150
Dolomite of fine texture, some light green, some nearly white in color. Both have imbedded angular quartz grains	2160

	Depth in Ft.
Yellowish light grey sandy dolomite	2185
Some pinkish-yellow and some greenish dolomite containing varying quantities of angular quartz sand	2185–2225
Light grey dolomite, in part with imbedded sand. Opalescent quartz, crystalline quartz and grey chert present	2215
Cream yellow dolomite, hard and effervescing very slowly. In thin section it is seen to have the crystals arranged in clusters about one-fourth mm. in diameter. Some white quartz present. Some of the sample consists of dolomite containing much sand	2260–2290
White dolomite, in part sandy	2265
Yellowish-grey dolomitic limestone. In thin section it is seen to be mostly crystalline and to contain many irregular rounded spots. Some of the spots are indistinct	2290–2325
Light grey dolomite of fine compact texture	2295
Yellowish-grey limestone of fine texture	2325–2337
Yellowish-grey marly limestone. Much fossiliferous chert present Brachiopod spines, echinoid spines, Fusulina and other organic fragments noted. In thin section the rock is seen to contain many small isolated calcite crystals. Septate tubes about one-sixteenth mm. in diameter are numerous in one section	2337–2345
Light grey limestone of finely crystalline texture. In thin section it is seen to contain imbedded fragments of fossils. A Fusulina and a piece of palechinid stem noted. Chert noted	2345
Grey limestone containing chert and many remains of brachiopods, such as fragments of ribbed valves, pieces of spines and one entire small Brachiopod (Hustedia?)	2360
Grey limestone of fine texture containing spicules of sponges, spines and fragments of valves of Pugnax and other brachiopods, and crinoid joints	2370
Grey limestone containing some chert and many fragments of Brachiopods. Crinoid joints noted	2376
Dark grey limestone with some chert and with many fragments of Brachiopods. A Bryozoan noted. Driller's note: "Change in material"	2382
Light grey limestone containing many remains of Brachiopods. Crinoid stems and a Bryozoan noted. In thin section rock is seen to consist of a granular crystalline matrix in which are imbedded some angular sand grains. Waagenoceras horizon of Glass Mountain section (?) J. A. Udden	2414
Dark grey fossiliferous limestone	2440

	Depth in Ft.
A grey rock consisting of about one-half sand and one-half calcareous, rather soft material	2465
Grey limestone. In thin section it is seen to contain particles of calcite. Fusulina also seen in the thin section. Brachiopod fragments and spines, crinoid stems(?), and sponge spicules noted in the washed and screened sample	2480–2570
Dark grey soft mixtures of shaly material, lime and fine sand. Minute mica scales noted. Fusulina and other fossil fragments noted	2510
Dark grey calcareous and shaly rock of even texture. Syringopora and Brachiopod spines noted	2520
Somewhat dark grey limestone. In thin section it is seen to contain many angular and fractured grains of sand and obscure traces of fossils. The rock contains some sponge spicules	2525
Grey shaly sandstone, very slightly calcareous. The sand is very fine in texture. In some of the largest flat cuttings there are dark bands on the bedding planes, reminding of the "worm-tracks" seen on the fine sands of the Word formation in the Glass Mountains	2530
Grey, shaly, calcareous and sandy rock and some light grey limestone	2550
Grey marly limestone giving faint odors of bitumen, ammonia and sulphur in closed tube. In thin section the rock is seen to be organic fragmental with inter-spaces filled with crystalline calcite. Fossils noted: spines of brachiopods and of palechinids, Fusulina and ostracods	2555
Dark grey calcareous sandstone of fine texture	2570
Grey marly limestone. Some pyrite present. Heated in closed tube gives faint bituminous fumes and faint fumes of ammonia. Brachiopod spines, Fusulina and other organic fragments noted	2570
Greenish-grey silt rock, fairly hard and calcareous. Exceedingly minute mica scales noted	2595
Dark grey limestone. In thin section it is seen to contain many angular and rounded quartz sand grains. The rock is minutely micaceous. Sponge spicules, some of which are pyritized, noted	2615
Grey shaly sandstone, slightly calcareous. The sand is very fine in texture. Some dark bands noted on the bedding plane in the largest fragments. Evidently laminated	2632
Dark grey, fine-grained, slightly calcareous, shaly sandstone and some fragments of darker sandstone with	

Depth in Ft.

coarser texture. The coarser sandstone is even textured and slightly calcareous. It is made up of rounded quartz grains about one-half mm. in diameter. Some dark bands noted on the bedding planes of the lighter colored rock. Evidently laminated 2660

Grey silty shale, slightly calcareous. Most of the grains are below one-sixteenth mm. in diameter. Mica very scarce. Grains angular 2670

Grey, shaly, fine-grained sandstone, slightly calcareous. It is minutely micaceous. Some pyritized sponge spicules noted 2676

Grey, shaly, fine-grained very slightly calcareous sandstone. Some dark bands noted on surfaces cutting the bedding planes. The rock is very minutely micaceous 2373

Like the preceding 2744

Grey dolomitic limestone containing much clear quartz sand and yellow dolomitic limestone. Driller's note: "Oil showing" 2767

Yellow and grey dolomitic limestone containing some clear quartz sand grains. Driller's note: "Water" 2775

Yellow dolomitic limestone containing some clear quartz sand grains. Heated in closed tube gives very strong fumes of bitumen. Driller's note: "Oil showing" 2781

Yellow dolomitic limestone containing some clear quartz sand grains. Driller's note: "Water" 2787

Yellowish and grey dolomitic limestone. In thin section it is seen to consist of a finely crystalline matrix in which are imbedded large and clear but irregular crystals 2798

Yellow limestone, somewhat dolomitic. Heated in closed tube it gives fumes of sulphur and small drops of oil. Driller's note: "Water" 2799–2815

Yellow dolomite. The crystals measure about one-sixteenth mm. in diameter. Heated in closed tube emits strong fumes of bitumen. Driller's note: "Oil showing" 2804

Yellow dolomite, crystals measuring about one-sixteenth mm. in diameter 2820

Like the preceding 2863

Brown sand with some dolomitic limestone and some gypsum or anhydrite 2873

Brown sand, grains mostly from one-sixteenth to one-fourth mm. in diameter 2877

Brown sand grains, mostly from one-fourth to one-sixteenth mm. in diameter 2880

	Depth in Ft.
Limestone, dolomite and chert. The latter shows minute (organic?) structures. Strong bituminous odor and sulphur fumes noted	2884
Yellow, somewhat dolomitic limestone. Rounded sand grains noted	2896
Brown sand and limestone with some chert. Bituminous odor and strong sulphur fumes in closed tube test	2903
White limestone with some grey fine-textured sandstone and some dolomite	2914
White limestone with some dolomite and sand with a few fragments of dark grey stony shale	2917
Grey limestone with chert. The limestone has organic fragmental texture. Several brachiopod spines noted. Fusulina present	2986
Grey and white limestone. In thin section it is seen to be mostly granular in texture, with fragments of Fusulina and Bryozoa. Several spines of brachiopods noted. White chert present. Odor of bitumen and sulphur in closed tube	2995
Dark, almost black, hard, calcareous and shaly rock. Heated in closed tube it gives drops of oil and weak fumes of ammonia. The bituminous fumes have the odor of peat or coal. Some of the fragments sustain a flame. In thin section it is seen to have a uniform fine texture and to contain obscure traces of sponge spicules. Broken fragments of large sponge spicules present, and other organic fragments noted	3009
Dark grey almost black, bituminous, shaly and calcareous rock of fine texture. In thin section it is seen to be of even texture. In closed tube it gives drops of oil and weak fumes of ammonia. Fossils: sponge spicules	3014
Another sample consisted of dark grey limestone imbedded angular silt or fine sand. Most of the rock effervesces very slowly in acid. Some of the lighter fragments effervesce briskly. Some light calcareous fragments show an irregular network of minute tubules apparently filled with some granular substance. This remains after digestion in acid. In closed tube ammonia fumes and strong bituminous fumes were noted	3014
Dark rock consisting of indurated bituminous and slightly calcareous mud. Yields the odor of coal or peat when heated in closed tube. Sponge spicules noted	3018
Another sample consisted of gray to very dark gray bituminous limestone which effervesces very slowly in acid. In thin section it is seen to contain much angular	

Depth in Ft.

fine sand and silt. Pyrite present. Fragments of siliceous spines (agatized) noted. Very obscure longitudinal flutings were observed on some, and most of them show a tendency to fracture obliquely at the ends. Probably small spines of echinoderms 3018

Dark bituminous silt rock. Large sponge spicules noted 3016–3020

Dark grey, dolomitic and bituminous rock containing some clear quartz sand. Large sponge spicules present. Gives bituminous odor when heated in closed tubes 3026

Like the preceding 3029

Dark grey, dolomitic and bituminous rock. Some silt present, as seen in thin section. Large sponge spicules noted. Yields odor of coal in closed tube 3034

Very dark grey rock consisting of angular grains of quartz in a matrix of dolomitic bituminous and argillaceous material. In closed tube it gives drops of oil and a coaly odor. Spicules noted ..... 3039 —

Gray and dark gray coarse silty shale, quite indurated. The material effervesces very slowly in dilute hydrochloric acid. In thin section much sand and silt in a shaly matrix is seen. No fossils were noted. In closed tube ammonia fumes and enough bitumen to sustain a flame were given off ..... 3043 —

Dark, in part almost black, bituminous silt rock, more or less dolomitic. Some fragments sustain a flame. Spicules of large size noted 3050

Gray and very dark gray limestone, effervesces very slowly in acid and seen in thin sections to contain fine sand and silt. Agatized spicules of sponges (?) and spines noted. On heating in closed tube gives strong bituminous fumes and drops of oil 3057

Gray and dark gray bituminous limestone like that from 3018. In thin section of one fragment many irregularly shaped brownish bodies are seen surrounded by a clear matrix 3070

Dark gray bituminous and dolomitic limestone containing some chert. Fragments of large sponge spicules present 3080

Very dark gray sandy and silty indurated shale. In thin section some fragments show rather large sponge spicules with bituminous material filling the cavities. An undetermined foraminifer noted. The sponge spicules and some of the material surrounding them appear to be siliceous. In closed tube strong ammonia fumes and very strong bituminous fumes were noted 3081

Black bituminous shale or shaly limestone with some gray limestone. In thin section it is seen to contain angular

Depth in Ft.

silt with some calcareous material imbedded in which are many sponge spicules, the original material of which has been replaced by agate-like quartz. Heated in closed tube, gives off strong bituminous fumes and large drops of red oil. Also fumes of ammonia 3086

An indurated very dark greenish-gray silt, containing some calcareous and some bituminous material. In thin section one sponge spicule was noted. On heating in closed tube it gives no fumes of ammonia but strong fumes of bitumen, which will sustain a flame and has a peaty odor 3090

Very dark gray bituminous sandy silt and shale. Two fragments in thin section show large sponge spicules with a large central cavity which is filled with bituminous material. Other fragments show fine sand grains and silt in a shaly matrix. An occasional crystal apparently of calcite is also seen in some fragments. The material as a whole effervesces slowly in dilute hydrochloric acid. Some fragments are cut by small veins resembling silica. Some fragments of chert noted. In closed tube ammonia fumes and very strong bituminous fumes noted. Fumes sustain a strong flame and leaves a deposit in tube 3091

Dark gray to black sandy silty shale which effervesces slowly in acid. Like sample from 3091. Some pyrite present. In closed tube strong ammonia fumes and very strong bituminous fumes were noted. Fumes sustain a flame and leave a deposit in tube 3096

Dark gray sandy silt which effervesces very slowly. Occasional sponge spicules of varying sizes are seen in washed material. In closed tube ammonia fumes were noted 3100

Very dark indurated sand and silt containing some chert. Some large sponge spicules present. In closed tube strong ammonia fumes and bituminous fumes sufficient to sustain a strong flame were noted 3105

Very dark indurated sandy silt. Effervescence is very slow in acid. In thin section sponge spicules having a bituminous filling in the central cavity and other irregular areas of bituminous material were noted. Some areas of finely spotted texture possibly crinoid tissues are seen in some fragments. In closed tube fumes of ammonia and very strong bituminous fumes were noted 310–

Gray to white slowly effervescing limestone finely ground up. In thin section some areas of crystalline dolomite

	Depth in Ft.
seen. A grain of glauconite and numerous sand grains also noted. No fossils were seen. In closed tube fumes of bitumen or ammonia were noted	3112
Gray to white dolomite with some white chert present. No fossils were seen	3120–3136
Gray to white dolomite with some fragments of chert. No fossils were noted	3136–3142

The upper 1100 feet of this well is regarded as Mesozoic, of which the upper 260 feet is typically Comanchean. From 390 feet down to 1090 feet, the samples examined are different from any Mesozoic seen by the writer in Texas, but contain undoubted Mesozoic fossils. The samples seen from below 1100 to 2140 feet are to be correlated with the Red Beds farther north. An unconformity is suggested as occurring at about 2140 feet, and the next 150 feet correspond to the Vidrio section of the Glass Mountains. From 2340 to 3050 feet the rocks represented, no doubt, belong to the Word formation of the Glass Mountain section.

A great deal of difficulty was encountered in shutting off the water at 3044 feet, but after about eight months' work it is reported that the water was finally shut out and that drilling was resumed. J. A. Udden.

Description of Samples from the Oregon-Texas Company's Well, Southeast Quarter of Section 19, Block 140, T. & St. L. Ry. Co., 800 Yards East of Grant Wells, Pecos County. Submitted by Wm. Blakeslee. Described by J. A. Udden and C. H. L., June 30, 1921

	Depth in Ft.	
White caliche	——	20
White floury caliche, with some quartz sand	20	30
Very pure white caliche of exceptionally fine texture	30	50
Gravel, consisting of black flint, limestone, sandstone and vein quartz. Sizes of pebbles up to one-half inch in diameter	50	60
Brownish and purplish silty clay; a few scales of mica present. Apparently Triassic red beds. (From bit)	60	65
Red sand of a fine texture	65	70
Laminated purplish-red sandstone and red silt and clay	70	80
Red soft sandstone of fine texture. Slightly micaceous	80	90
Very fine-textured faintly purplish-red sandstone and some red clay. Circular white spots noted	90	100
Red, fine-grained sandstone in part laminated with minute mica scales in the seams. Circular white spots noted	100	110

	Depth in Ft.	
Purplish-red sandy clays. Some white sandstone present	110	120
Red and white marly clay	120	140
Red and white marly clay	140	150
Red and white marly clay	150	160
Bluish, light gray, clay silt	160	190
Fine-textured sandstone bluish and reddish, and some red marly clay	190	180
Bluish, dirty gray silt, and fine sand	180	200
Light gray silty and somewhat indurated sandstone, laminated ,lamina measuring five mm. Mica present	200	210
Like the preceding	210	220
Granular gray limestone containing some sand and anhydrite. Much pyrite is present, mostly disseminated throughout the sample	220	226
Light gray indurated silt with some very fine grains of sandstone, impregnated with pyrite. A pyrite concretion noted, and some calcareous material	226	230
Light gray dolomite, very compact in texture. Dfficult to dissolve in acid, but it dissolves completely. The sample is quite free from other material. In thin section the dolomite appears to consist of crystals of somewhat variable size	230	240
Fine sand and gypsum with some calcareous material	240	245
"Mortar rock," a sandstone of fine texture in which the grains are held together by a calcareous substance which appears to be 50 per cent of the rock. Much pyrite is present and there are some fragments of almost black, highly pyritiferous material. Yields strong bituminous fumes when heated in a closed tube	245	256
Like the preceding	256	260
Gray silty sandstone cemented with considerable lime. In thin section the limestone is seen to consist of crystals one-twenty-ninth mm. in diameter. Many with dark center	260	270
Like the preceding, but laminated	270	280
Gray dolomite containing some sand	280	286
Porous limestone, siliceous, containing some fine sand and other siliceous material. Pyrite present	286	330
Brown clay and white gypsum	330	350
Mostly white gypsum, some gray limestone	350	360
White anhydrite	360	370
White anhydrite	370	380
Like the preceding	380	400
Like the preceding	400	410
White anhydrite and some greenish marl	410	430

	Depth in Ft.	
Anhydrite with some green clay and some calcareous material present	430	450
White anhydrite	450	460
A mixture of blue and light brownish-yellow gypsiferous clay containing some limestone, anhydrite and gypsum	460	470
Sample consists of one piece of gray anhydrite, two pieces of satin spar gypsum, one piece of selenite	470	475
White anhydrite, red and green clay	480	
Like the preceding	485	
Like the preceding	488	
Like the preceding	490	
Like the preceding. Some fibrous gypsum noted	500	
Like the preceding	510	
Like the preceding	520	
Like the preceding	530	
White anhydrite	540	
Like the preceding	550	
White anhydrite	560	
White anhydrite	570	
Like the preceding	580	
Like the preceding. Some red gypsum noted. Brown clay	590	
White hard anhydrite. Some red gypsum	600	
White and gray anhydrite	610	
White anhydrite	620	
White anhydrite	630	
White anhydrite	640	
White anhydrite. Some fibrous gypsum	650	
White anhydrite. Some reddish selenite	660	
White anhydrite. Some clay noted	670	
White anhydrite	680	
White anhydrite	690	
Bluish light grey clay. White anhydrite. Some brick red anhydrite	700	
White anhydrite	710	
White and gray anhydrite	720	
White anhydrite	730	

Samples from Thomas 1 (= Trans-Pecos 5), Section 6, Block 114, G. C. & S. F. Ry., Pecos County. Samples Described by W. S. Adkins. Elevation 2877 Feet, T. D. 1825 Feet

	Depth in Ft.
Grayish limestone with some subrounded quartz sand	260–300
(Top of Basement Sand of Cretaceous at 270.)	
White, subangular to subrounded quartz sand with calcareous cement; some pyrite; no *Chara* noted	370

	Depth in Ft.
Mostly fine subangular, clear quartz sand with some calcareous cement; some pyrite; no *Chara* noted	384
Similar to 384	410
Similar to 384; most grains pass a 40-mesh	423–426
Gray-brown limestone; pyrite; quartz sand as subrounded grains in a calcareous cement. No fossils seen	432
Fine subrounded quartz grains with considerable calcareous cement. No fossils seen	435
Subrounded quartz grains with some calcareous cement; some pyrite. No fossils seen	474
Fine subangular quartz grains and some calcareous cement. No fossils	482
Similar to 474	487
Fine, subangular to coarser, subrounded quartz grains with some calcareous cement. No fossils seen	492
Like 482, but quartz grains coarser	500–506
Medium, subrounded quartz grains in calcareous cement; pyrite, chert. No fossils seen	514
Similar to 514	517
Fine quartz sand with calcareous cement. No fossils seen	530
(Bottom of Basement Sand of Cretaceous 547.)	
Clayey sandstone, consisting of reddish and amber-colored quartz grains, subrounded with calcareous cement; pyrite and chert. No *Chara* fruits	547
Red sandy clay, with a residue similar to 547, but redder. No *Chara*	580–585
Clayey sandstone residue, similar to 580–585	597
Sandy clay. Similar to 580–585	622
Similar to 580–585, but grains smaller	648
Reddish clayey sandstone, with fine, subrounded quartz grains in a clay or silt matrix; some pyrite. No fossils seen	652
Reddish silty shale; pyrite. No fossils	652
A mixture of limestone, pyrite, quartz grains, and some grayish and reddish sandstone consisting of subrounded quartz grains in a calcareous cement	656
Reddish clay with grains of subrounded quartz, chert and other minerals. Some gray and reddish sandstone, composed of subrounded quartz grains with calcareous cement; some pyrite	680
Mostly reddish clay with subangular and subrounded quartz grains and a small amount of pyrite	720
Similar to 720	754
Similar to 720	762
Similar to 720	780

Similar to 720	823–828
Similar to 720	828–834
Mainly dark reddish-brown sandstone, and a quantity of fine, subangular to subrounded, clear, rose and amber colored quartz grains	834–840
Similar to 834–840	840–845
Dard reddish-brown clay with a small amount of quartz grains and anhydrite	875–900
Mainly dark reddish-brown sandstone and much subangular and subrounded quartz grains. A considerable quantity of subrounded grains of *magnetite*, nearly all of which pass through a 40-mesh screen	880
Mainly red-brown; some quartz grains and anhydrite	905–910
Mainly lighter, reddish-brown clay	960–965
Deep reddish-brown clay with some quartz grains and anhydrite	1085
Two samples, both deep reddish, fine-grained sandstone and and sandy clay, with a small amount of subrounded quartz grains and some fibrous gypsum	Depth in Ft. 1100
Similar to 1100	1120
Similar to 1100	1125
Similar to 1100, but duller in color	1170
Dark, brownish-red sandstone, and a considerable quantity of subangular and subrounded quartz grains	1175–1180
Light reddish-brown, fine-grained sandstone and some sandy clay, with some subrounded quartz grains and some gypsum	1185–1190
Mainly light reddish, fine-grained sandy clay	1245–1250
Mainly dark red-brown, sandy clay; some gypsum	1280–1285
Mainly dark red-brown clayey sandstone; some gypsum	1295–1300
Similar to 1295–1300	1345
Mainly reddish silty clay; some gypsum	1345–1350
Similar to 1345–1350	1365–1370
Similar to 1345–1350	1405
Mainly clear anhydrite, with some gypsum and some material which consists of a mixture of anhydrite crystals with a small amount of calcium carbonate	1420–1425
Mainly clear anhydrite with some reddish clay	1430–1435
Mainly anhydrite; considerable subrounded frosted quartz grains; some reddish-brown quartz sandstone with slightly calcareous cement; some chert grains	1440–1445
Similar to 1440–1445	1455
Anhydrite and some reddish-brown sandstone	1475
Anhydrite and a small amount of reddish-brown sandstone	1480–1485
Similar to 1480–1485	1490–1495

	Depth in Ft.
Reddish-brown silty clay with some anhydrite and quartz grains	1495–1500
Mainly anhydrite mixed with a small amount of calcium carbonate; some rounded quartz grains and some pyrite; some reddish sandstone; some fibrous gypsum	1503
Mainly brownish-gray limestone, and a small amount of reddish sandstone	1525
Mainly anhydrite; some sandstone and quartz grains	1530
Mainly brownish limestone; two pieces of light blue clay; some reddish sandstone, pyrite and subrounded quartz grains	1530–1535
A sand composed of subrounded quartz grains, with pieces of limestone and anhydrite	1535–1540
Mainly limestone with grains of quartz, anhydrite and magnetite	1535
Mainly anhydrite with a considerable amount of subrounded quartz grains; color of sample reddish	1550
Similar to 1550	1565
Mainly anhydrite; some limestone, fibrous gypsum red sandstone	1595
Mainly anhydrite; some red-brown sandstone and fibrous gypsum	1595–1600
Reddish-brown, sandy, calcareous shale, with some limestone, anhydrite, fibrous gypsum and pyrite	1600–1605
Mainly reddish-brown silty calcareous shale; some limestone, anhydrite, fibrous gypsum, pyrite, and red, noncalcareous sandstone	1608
Mainly reddish-brown sandstone; some gray sandstone with calcareous cement; some limestone, anhydrite and pyrite; considerable fibrous gypsum	1610–1615
Similar to 1610–1615	1612
Grayish limestone and a little gypsum	1615–1618
Grayish limestone, some reddish clay, and a little gypsum	1627
Mainly reddish-brown, sandy, calcareous clay; some greenish clay and some gypsum	1632
Mainly light grayish-brown limestone; its insoluble residue consists mainly of fine quartz grains, and some tourmaline, zircon, muscovite, altered biotite, and several other detrital minerals; a little pyrite and anhydrite	1645
Mainly light grayish-brown limestone; some pyrite; red-brown sandstone, and subrounded quartz grains	1645–1650
Light grayish-brown limestone, with some pyrite; residue similar to 1645	1655–1660
Light grayish brown limestone; some pyrite; residue similar to 1645	1666

	Depth in Ft.
Similar to 1645	1675
Similar to 1645	1680
Mainly anhydrite; some reddish and greenish clay; pyrite	1695
Dull reddish, sandy clay; some pyrite	1698
Reddish clay and sandstone; some anhydrite and subrounded quartz grains	1700
Dull reddish clay; some anhydrite and fibrous gypsum	1718
Mainly anhydrite, some dull reddish clay	1720
Mainly anhydrite, some contains calcium carbonate; pyrite	1730
Mainly anhydrite; some fibrous gypsum	1740
Mainly anhydrite; some fibrous gypsum and pyrite	1745
(Log reports red shale, 1750–1762.)	
Mainly anhydrite; considerable subrounded quartz and magnetite grains; some pyrite	1760–1765
White and gray anhydrite; some pyrite	1775–1780
Mainly light grayish-brown limestone; some magnetite and some anhydrite	1775
Bluish clay and some anhydrite	1780–1785
Gray anhydrite; some magnetite	1790
Gray anhydrite; a small amount of magnetite	1810
Gray anhydrite	1815
(T. D. 1825)	

Description of Sample from Troy Well, Section 19, Block 140, T. & S. L. Ry. Survey. Sample Submitted by Frank R. Campbell, Laredo, Texas. Described by D. D. Christner

	Depth in Ft.
White and grey very fine-grained dolomitic limestone. Some of the fragments are fairly well impregnated with bituminous material. Some anhydrite is present as replacements in the dolomite. Permian	2725

Description of Samples from the I. G. Yates Well No. 1, Mid-Kansas Oil and Gas Co., Located 2900 Feet Due West of the Southwest Corner, Section 60, I. & G. N. Ry. Survey, Block l, Near the Pecos River, About 12 Miles North of Sheffield, Pecos County Submitted by Frank R. Clark, Mid-Kansas Oil and Gas Co., Tulsa, Oklahoma. Described by O. M. Richey

	Depth in Ft.
Sample consists principally of cuttings of anhydrite. A little gypsum and pyrite noted	515–635

	Depth in Ft.
Sample consists largely of cuttings of anhydrite. Gypsum and pyrite present. A few fragments of brown dolomitic limestone noted. Note accompanying sample: "Show of oil."	635–645
Sample consists of cuttings of medium gray, slightly calcareous medium-grained sandstone and some anhydrite. A little gypsum and pyrite present. Worn almost round quartz grains measuring three-fourths mm. in diameter noted	645–805
Sample consists of cuttings of anhydrite and medium gray, slightly calcareous, medium-grained sandstone. Gysum and pyrite present	805–850
Sample consists of cuttings of gray sandstone, brownish-gray dolomitic limestone, anhydrite, gypsum, and a little pyrite. Note accompanying sample: "Show of gas."	850–880
Like sample from 850–880	830–946
Like sample from 850–880. A few almost perfect clear quartz crystals noted	945–975
Sample consists of cuttings of medium and dark dolomitic limestone and some gray sandstone. Note accompanying sample: "Show of oil."	975–985
Like sample from 975–985. A little pyrite present. Note accompanying sample: "Oil."	985–995

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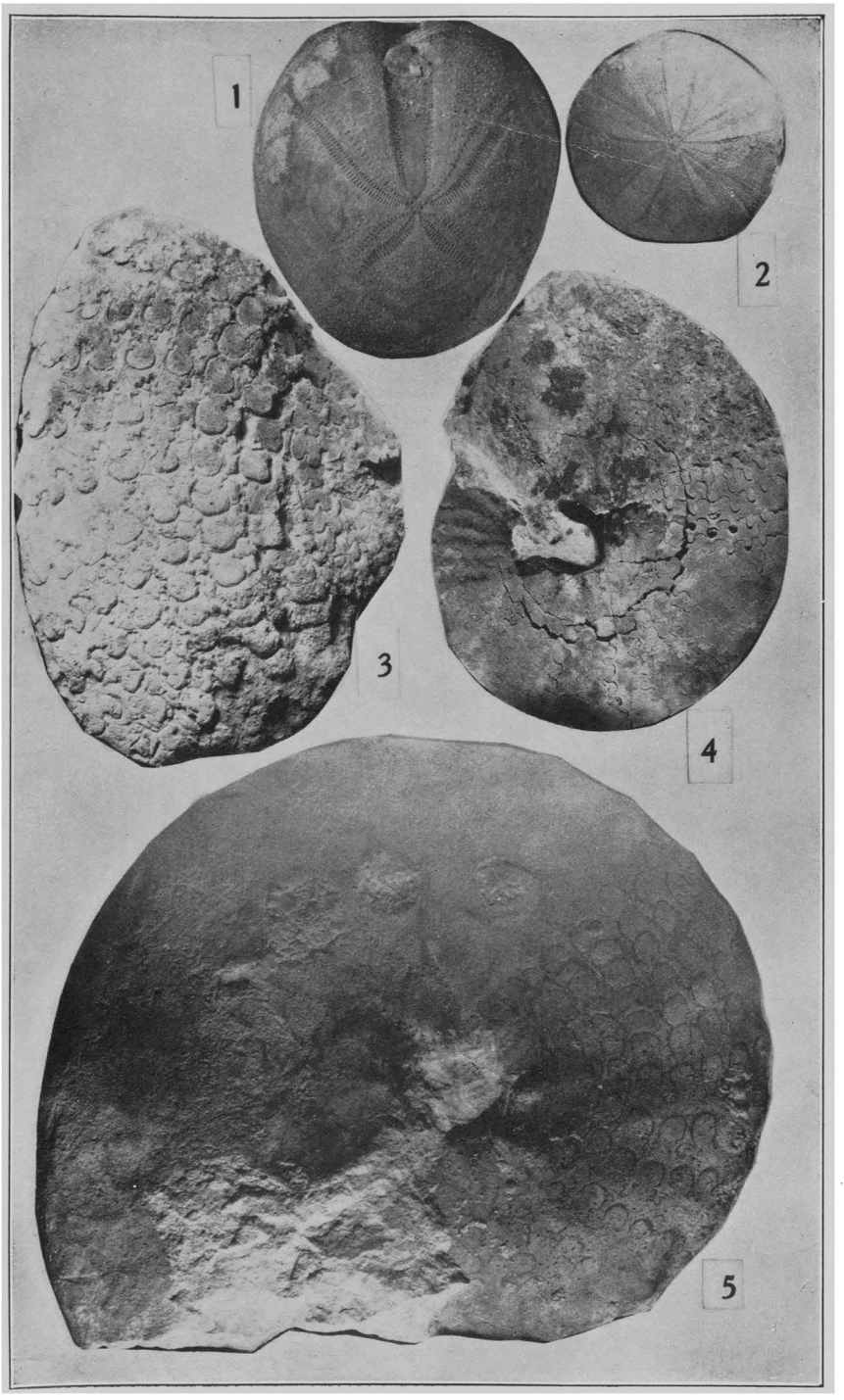

Fredericksburg Fossils. Fig 1. **Heteraster** cf. **texanus** (Roemer), x 1. Fig. 2. **Holectypus** cf. **planus** (Giebel), x 1. Fig. 3. **Metengonoceras hilli** Boehm. x 1. Fig. 4. **Engonoceras** cf. **piedernale** von Buch. x 1. Fig. 5. **Engonoceras stolleyi** Boehm, x. 0.9.

Plate 3. Fredericksburg and Duck Creek Fossils

Fig. 1. **Oxytropidoceras** cf. **acutocarinatum** (Shumard, 1854), x 1. Rare in the Kiamichi; frequent in the Fredericksburg clay beneath the Brown **Trigonia**-limestone seam. In Central Texas it ranges from the Walnut to the basal Duck Creek limestone. There are several closely related forms.

Fig. 2. **Oxytropidoceras** n. sp. (aff. **supani** Lasswitz, 1904), x 0.28. Horizon: Fredericksburg clay and Kiamichi. Locality: Comanche Springs.

Fig. 3. **Oxytropidoceras trinitense** (Gabb), **Holotype,** British Museum, South Kensington, BM 12665, x 0.75. Locality: Elm Fork of the Trinity River, probably in Cooke or Montague County. Horizon: Comanche Peak to Kiamichi. Frequent in the Fort Stockton area.

Fig. 4. **Pervinquieria kiliani** (Lasswitz, 1904), **Holotype,** x 1. Museum, University of Breslau. Horizon: Basal Duck Creek, and ?Fort Worth limestone. Type locality: I. & G. N. Cut, West Sixth Street, Austin. Frequent near Fort Stockton.

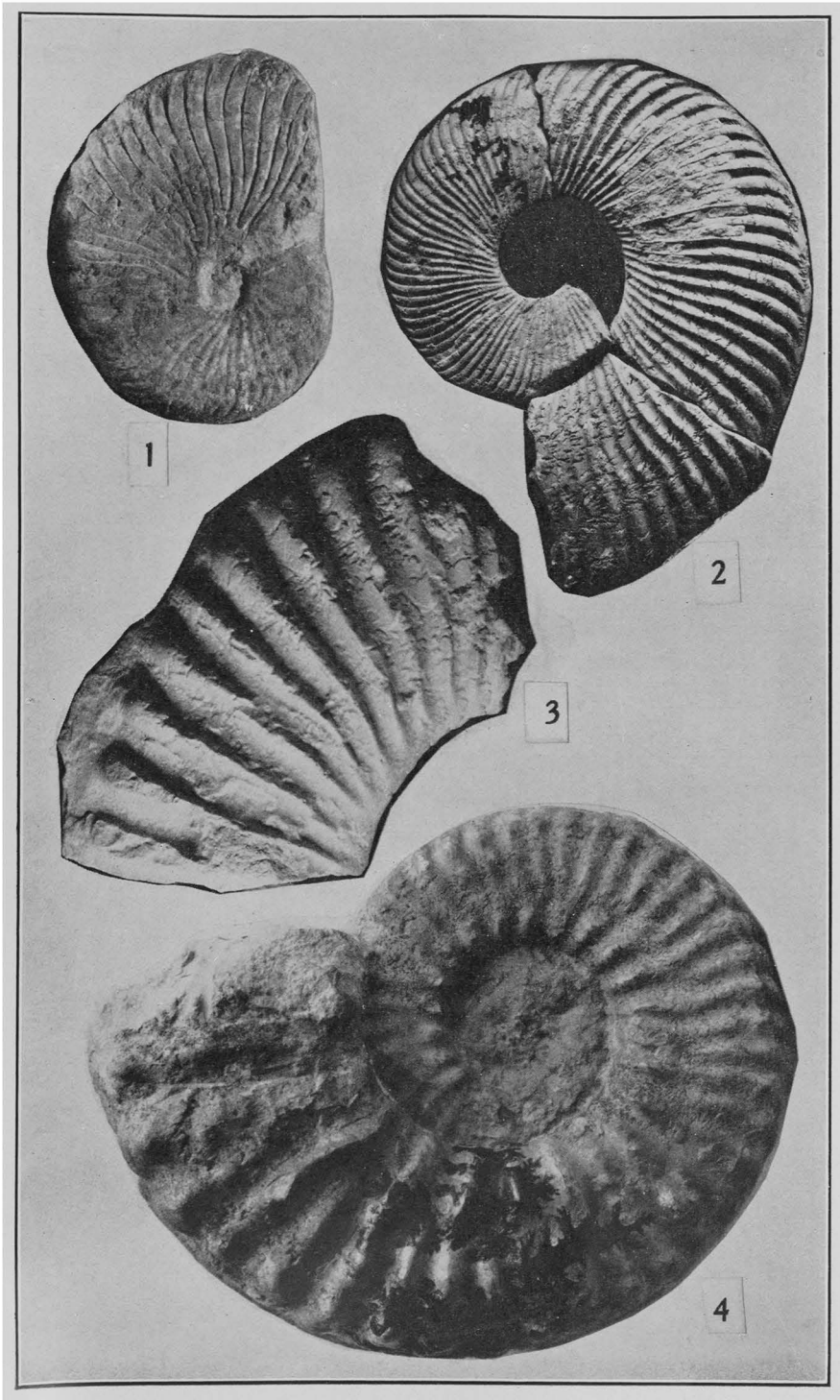
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Plate 4. Kiamichi and Duck Creek Fossils

Fig. 1. **Gryphea tucumcari** Marcou, 1858, x 0.75, **Holotype,** British Museum, South Kensington, BM12676. Type locality: Near Tucumcari, N. M. Horizon: Kiamichi and Lower Duck Creek, common.

Fig. 2. **Hamites fremonti** Marcou 1858, **Holotype,** BM12667, x 0.75. Type locality: Preston, Grayson County, Texas. Horizon: Basal Duck Creek; occasional.

Fig. 3. **Elobiceras** n. sp. x 1. Rare; Upper Kiamichi.

Fig. 4. **Oxytropidoceras** n. sp., x 0.85. Common; Comanche Peak limestone.

Fig. 5. **Oxytropidoceras** aff. **chihuahuense (Böse).** x 0.95. Common; Fredericksburg clay, Comanche Peak limestone.

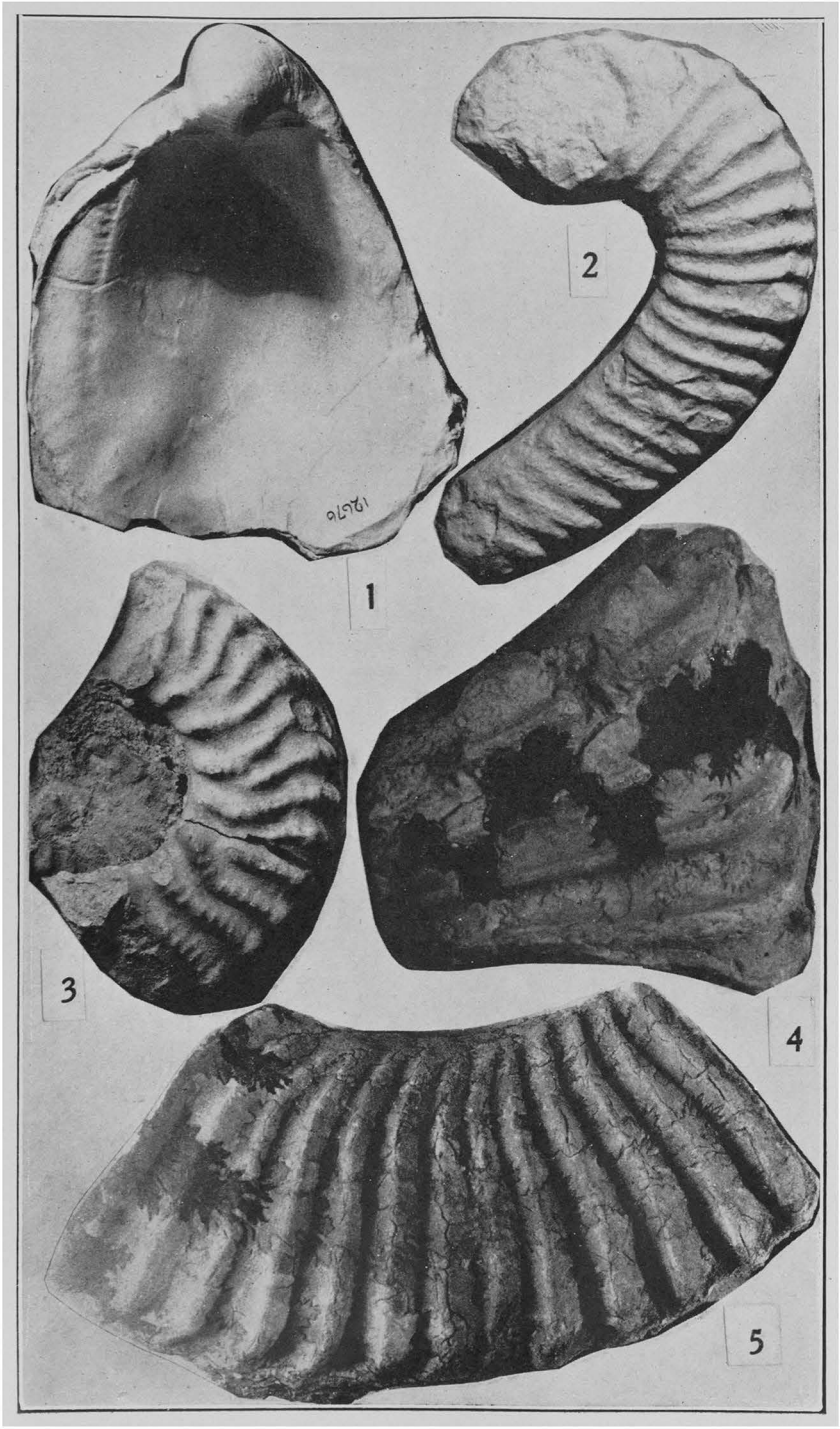
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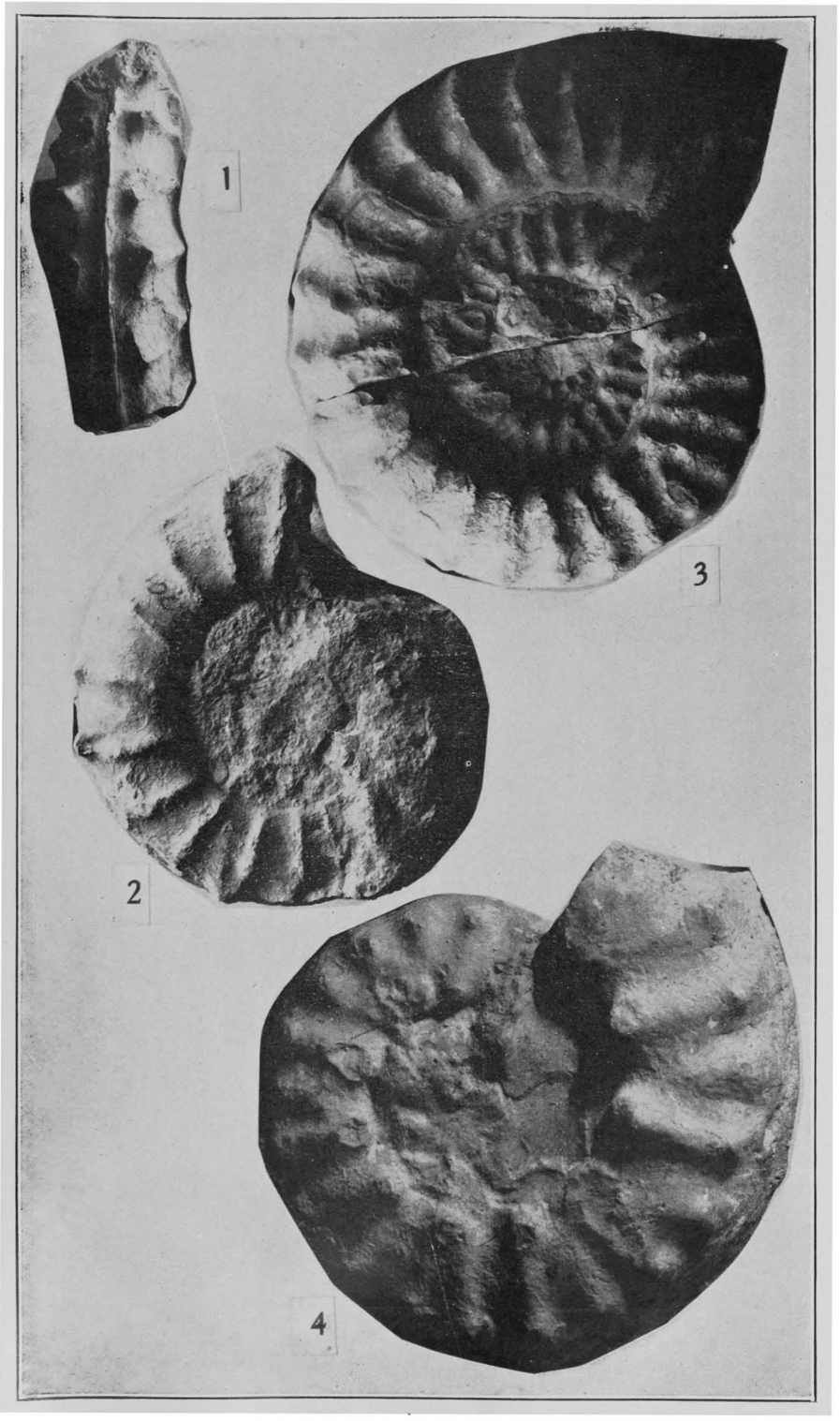
Plate 5. Duck Creek Fossils

Fig. 1–2. **Pervinquieria** n. sp. x 0.25. Duck Creek and Fort Worth.

Fig. 3. **Pervinquieria** n. sp. aff. **trinodosa** (Böse), x 0.25. Duck Creek.

Fig. 4. **Pervinquieria leonensis** (Conrad, 1857), **Holotype,** x 1. U.S.N.M., No. 9878, courtesy of Dr. T. W. Stanton. Type locality: Leon Springs. Horizon: Probably Duck Creek. Rare.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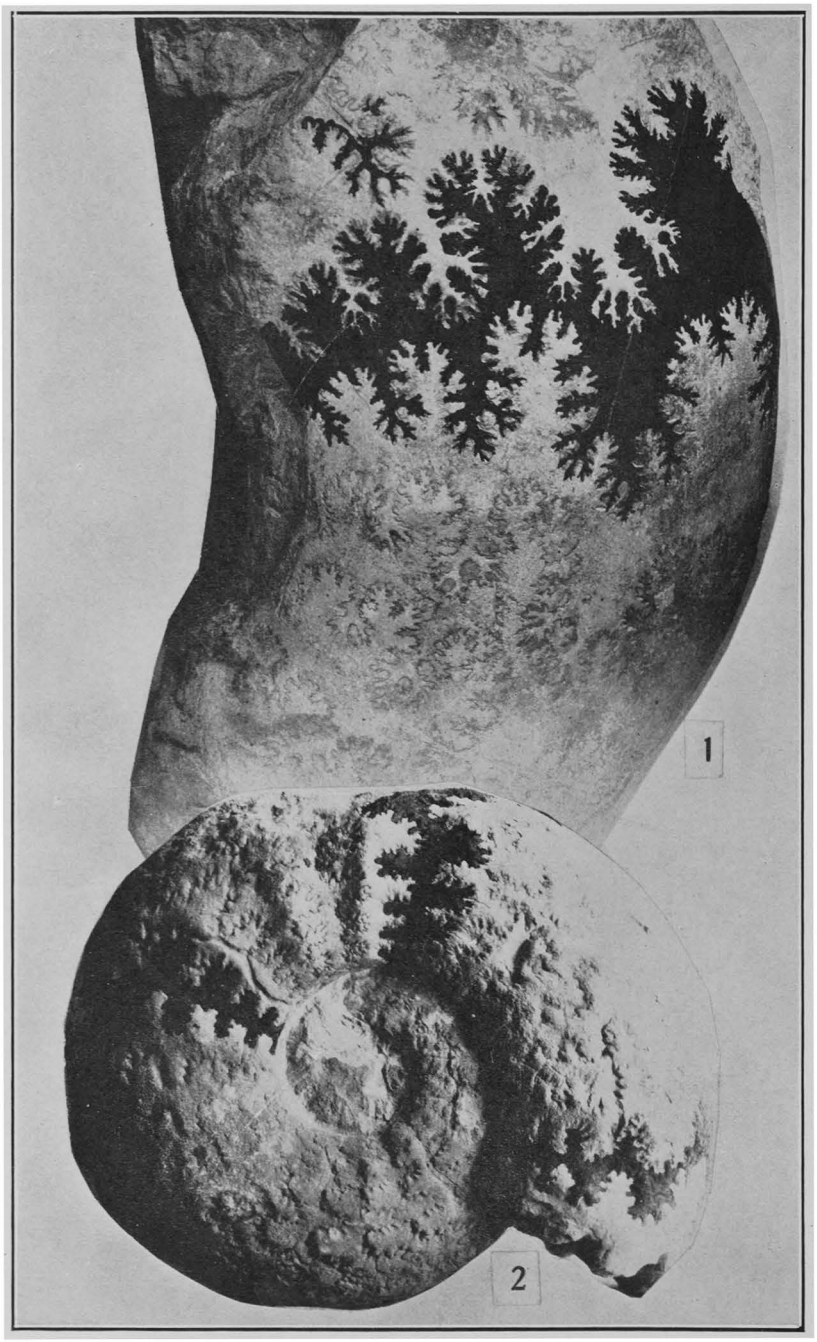
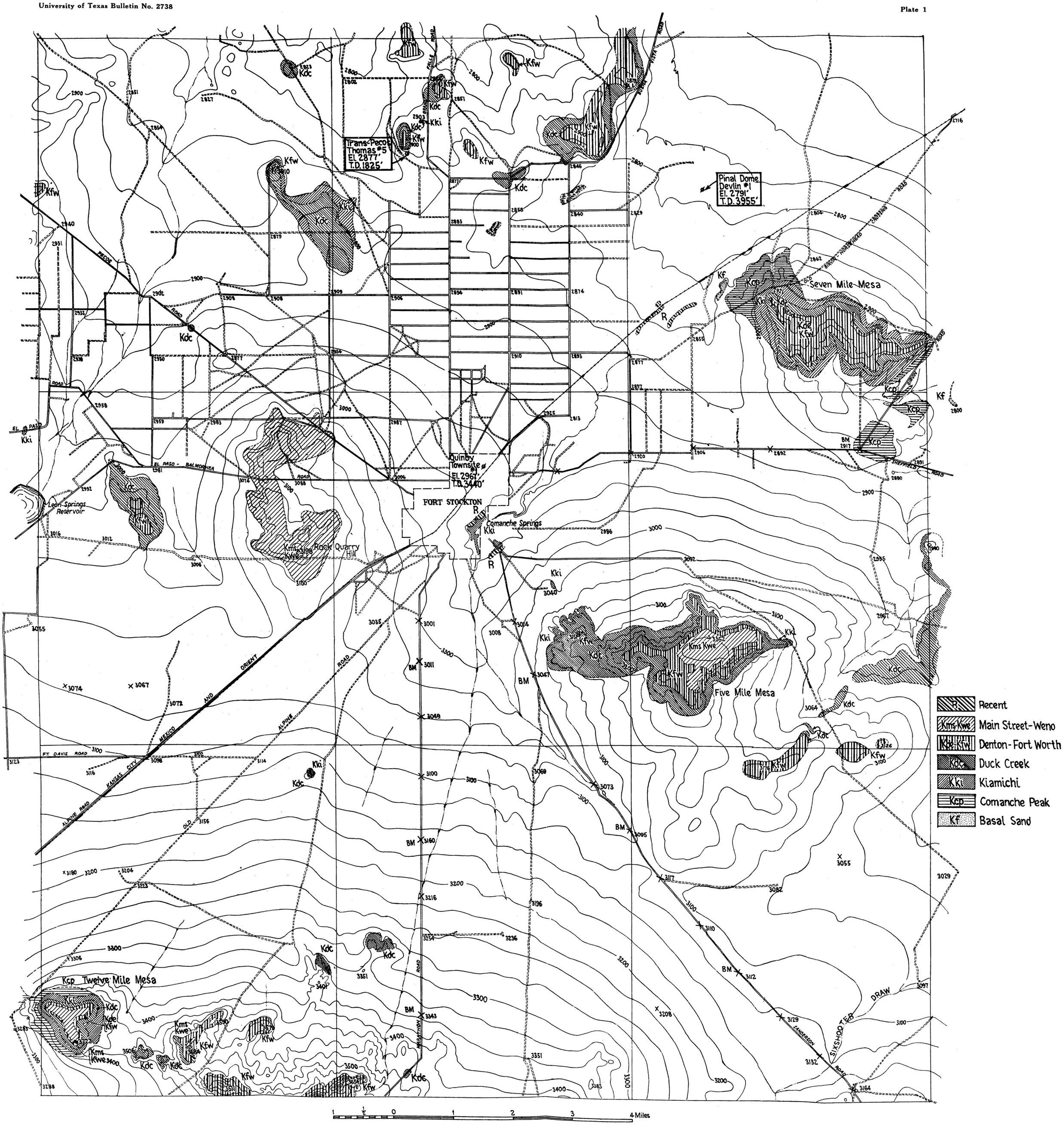


Duck Creek Fossils. Fig. 1. **Desmoceras laevicaniculatum.** Roemer 1904. x 0.9. Fig 2. **Desmoceras brazoense?** (Shumard). x 0.2.



GEOLOGIC MAP OF THE FORT STOCKTON QUADRANGLE

By W. S. Adkins, 1926

Scale: 1 inch=1 mile. Contour interval, 25 feet.

Topography from Fort Stockton Topographic Sheet of the United States Geological Survey.